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May 29, 2019

VIA ELECTRONIC FILING

The Honorable Jocelyn G. Boyd
Chief Clerk/Administrator
Public Service Commission of South Carolina
101 Executive Center Drive
Columbia, South Carolina 29210

RE: Dominion Energy South Carolina, Inc.
Application of South Carolina Electric & Gas Company for Approval to
Continue Demand Side Management Programs and Included Rate
Rider, and for Approval of Revised Portfolio of Energy Efficiency
Programs; Docket No. 2013-208-E

Dear Ms. Boyd:

In accordance with Order No. 2013-826 in the above-referenced docket, Dominion Energy South Carolina, Inc. hereby files with the Public Service Commission of South Carolina a copy of the Company's Evaluation, Measurement and Verification report ("EM&V Report") for Program Year 8, which consists of the time period December 1, 2017, to November 30, 2018.

By copy of this letter, we are also providing a copy of the EM&V Report to the South Carolina Office of Regulatory Staff and enclose a certificate of service to that effect. We are also providing counsel for the other parties in the above-referenced docket with a courtesy copy of the report.

If you have any questions, please advise.

Very truly yours,

A handwritten signature in blue ink that reads "Matthew W. Gissendanner".

Matthew W. Gissendanner

MWG/kms
Enclosure

The Honorable Jocelyn G. Boyd, Esquire
May 29, 2019
Page 2

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(all via electronic mail and U.S. First-Class Mail w/enclosure)

BEFORE
THE PUBLIC SERVICE COMMISSION OF
SOUTH CAROLINA
DOCKET NO. 2013-208-E

IN RE:

Application of South Carolina Electric & Gas company for Approval to Continue Demand Side Management Programs and Included Rate Rider, and for Approval of Revised Portfolio of Energy Efficiency Programs)	CERTIFICATE OF SERVICE
)	
)	
)	
)	
)	

This is to certify that I have caused to be served this day one (1) copy of Dominion Energy South Carolina, Inc.'s **Evaluation, Measurement and Verification ("EM&V") Report** to the persons named below at the addresses set forth:

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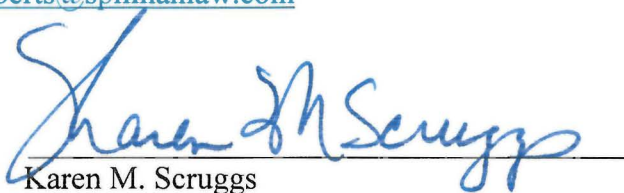
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Karen M. Scruggs

Cayce, South Carolina

This 29th day of May, 2019



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Dominion Energy South Carolina, Inc. EnergyWise Program Year 8: Evaluation, Measurement and Verification Report

Megan Campbell
Vice President
May 2019

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1. Executive Summary

Dominion Energy South Carolina, Inc. (DESC) began offering customer energy efficiency programs in October 2010. The period from December 1, 2017, through November 30, 2018, constituted their eighth program year (PY8). Over this period, DESC administered six programs for residential electric customers and two programs for commercial and industrial (C&I) electric customers. The purpose of this report is to provide ex-post PY8 gross and net program energy and demand savings estimates as compared to the company's forecasted and DESC reported (ex-ante) savings.

DESC forecasted gross savings of 69,492 MWH and 16.80 MW for the PY8 portfolio of energy efficiency programs. The evaluation found ex-post gross savings exceeded the energy savings forecast by 108% and fell slightly short of the demand forecast (92%). In PY8, DESC spent approximately \$13.6M dollars implementing these programs¹, just 2% more than the spending forecast. Table 1 presents gross savings, costs and participation for each program, comparing each to PY8 forecasts.

In PY8, DESC continued to help customers adopt more energy efficient lighting through an ENERGY STAR® Online Lighting Store, giveaways to customers visiting DESC business office locations and mailed LED bulbs to targeted customers in hard-to-reach areas. DESC continued to help income-qualified customers save energy and reduce energy bills by installing energy efficient lighting and other products through its Neighborhood Energy Efficiency (NEEP) Program. In addition, DESC continued to offer weatherization measures for income-qualified mobile home customers. Heating & Cooling, Appliance Recycling Program (ARP), Home Energy Check-up (HEC) and Home Energy Reports (HER) continued to serve residential customers in PY8 and the Small Business Energy Solutions (SBES) and EnergyWise for Your Business (EWfYB) Programs continued to help commercial customers seize energy efficient opportunities.

Some key highlights from this evaluation of the PY8 programs are bulleted below. These findings are further detailed in each program's chapter of this report.

- DESC increased the incentive levels for select equipment offered through the Heating and Cooling program in addition to sending more educational materials to participants on what further actions they can take in their homes to further reduce energy. These changes helped to increase the number of energy efficient units in the marketplace in PY8 and it also increased spillover savings and reduced free-ridership (FR) in the program.
- The NEEP program was able to exceed its forecasts for participation and energy savings while spending less than anticipated. The energy savings are quite significant for the mobile and manufactured weatherization component. The program was able to weatherize 100 mobile and manufactured homes in PY8 and the savings show that the program has the potential to save up to 13% of the average customer's annual usage.
- The SBES program continued to serve a significant amount of small businesses with both lighting and refrigeration measures. The amount of participation is less than forecasted and slightly less than previous years which is mainly due to some product availability issues in the first half of PY8.
- The HER program is in its 8th year of sending comparison reports to customers. After eight years of implementation, the evaluation results this year found that the savings per participant has decreased significantly over time. The program is likely in need of a redesign to help increase the behavioral savings that DESC can claim in the future from this type of program.

¹ Program costs reported here do not account for amortization or interest.

Executive Summary

This report contains a chapter for each program and presents the ex-post gross and net savings and a discussion of the program's performance compared to forecasts and ex-ante estimates.

Table 1. Portfolio Ex-Post Gross Savings, Costs and Participation

Program Name	Ex-Post Gross Savings				Program Costs		Participation		
	MWH Actual	% of Forecast	MW Actual	% of Forecast	Actual	% of Forecast	Actual	% of Forecast	Definition
ENERGY STAR® Lighting	5,690	72%	0.52	66%	581,763	43%	173,324	125%	Bulbs/Fixtures
Home Energy Reports	2,705	18%	0.96	16%	537,725	71%	42,197	100%	Customers / Households
Heating & Cooling	4,427	287%	3.18	291%	2,223,281	151%	5,130	100%	Measures
Neighborhood Energy Efficiency Program	4,090	185%	0.41	115%	1,391,090	140%	3,586	163%	Customers
Appliance Recycling	3,473	147%	0.40	137%	689,664	112%	3,267	106%	Customers
Home Energy Check-up	1,866	83%	0.26	56%	804,886	97%	3,460	103%	Customers
EnergyWise for Your Business	47,950	147%	8.25	137%	5,392,285	116%	767	114%	Projects
Small Business Energy Solutions	5,124	95%	1.48	81%	1,965,219	74%	461	70%	Projects
Total	75,325	108%	15.46	92%	\$13,585,913	102%	232,192	118%	

Notes: This report compares ex-post gross savings to PY8 forecasts stated in South Carolina Electric & Gas Company's Annual Update on Demand Side Management Programs and Petition to Update Rate Rider submitted in January 2019 to the Public Service Commission of South Carolina <https://dms.psc.sc.gov/Web/Dockets/Detail/117000>; program costs presented in the report do not account for amortization or interest (carrying costs).

Executive Summary

The overall portfolio achieved net savings (savings attributable to DESC's program offerings) of 55,843 MWH and 11.73 MW, which amounts to approximately three-quarters of the gross energy and demand savings. The net-to-gross-ratios (NTGRs) indicate that DESC's incentives and services are influencing the majority of customers to save energy.

Table 2. PY8 Ex-Post Gross and Net Savings

Program Name	Energy Savings			Demand Savings		
	Gross MWH Savings	NTGR	Net MWH Savings	Gross MW Savings	NTGR	Net MW Savings
EnergyWise for Your Business	47,950	0.70	33,524	8.25	0.74	6.10
ENERGY STAR® Lighting	5,690	0.75	4,287	0.52	0.75	0.39
Small Business Energy Solutions	5,124	0.95	4,865	1.48	0.98	1.45
Heating & Cooling	4,427	0.65	2,892	3.18	0.62	1.96
Neighborhood Energy Efficiency Program (NEEP)	4,090	1.00	4,090	0.41	1.00	0.41
Appliance Recycling	3,473	0.62	2,171	0.40	0.65	0.26
Home Energy Reports	2,705	1.00	2,705	0.96	1.00	0.96
Home Energy Check-up	1,866	0.70	1,309	0.26	0.77	0.20
Total	75,325		55,843	15.46		11.73

Note: Some values in this table do not sum or divide exactly due to rounding.

As shown in Table 3, most of the PY8 energy savings came from the EWfYB program followed by the Residential Lighting and Small Business programs.

Table 3. Program Contribution to Overall Portfolio Gross and Net MWH Savings

Program	Contribution to Gross MWH	Contribution to Net MWH
EnergyWise for Your Business	64%	60%
ENERGY STAR® Lighting	8%	8%
Small Business Energy Solutions	7%	9%
Heating & Cooling	6%	5%
Neighborhood Energy Efficiency Program	5%	7%
Appliance Recycling	5%	4%
Home Energy Reports	4%	5%
Home Energy Check-up	2%	2%

Table 4 compares the ex-post gross savings (total estimated savings, exclusive of FR and spillover) to the savings reported in DESC's Annual Update on Demand Side Management (DSM) Programs and Petition to Update Rate Rider submitted in January 2019 to the Public Service Commission of South Carolina (ex-ante). The PY8 impact evaluation found ex-post savings equal to 94% of the ex-ante energy savings and 89% of the ex-ante demand savings.

Table 4. PY8 Ex-Post Gross Realization Rates

Program Name	MWH			MW			
	Ex-Ante	Ex-Post	RR	Ex-Ante	Ex-Post	RR	
Home Energy Reports	6,665	2,705	41%	2.37	0.96	41%	Corrected database errors that reduced the number of participants and a billing analysis showed less savings on average per participant than previous years.
Home Energy Check-up	3,139	1,866	59%	0.59	0.26	44%	Corrected database errors, applied installation rates, calculated new savings beyond leave-behind measures based on energy savings actions that participants took after the audit.
ENERGY STAR Lighting	6,817	5,690	83%	0.57	0.52	91%	Applied installation rates, applied unrounded per-unit savings values, revised deemed savings assumptions for five new products in the Online Store in PY8, updated baseline assumptions for EISA impacted products.
Heating & Cooling	4,402	4,427	100.6%	3.17	3.18	100%	n/a
Neighborhood Energy Efficiency Program	4,116	4,090	99%	0.42	0.41	99%	Corrected database and rounding errors.
Appliance Recycling	3,319	3,473	105%	0.38	0.40	105%	Adjusted savings based on the size and age of PY8 recycled appliances.
EnergyWise for Business	46,841	47,950	102%	8.81	8.25	94%	Reasons for differences in savings vary by project and can be found in the Appendix.
Small Business Energy Solutions	5,118	5,124	100.1%	1.03	1.48	143.5%	Reasons for differences amongst lighting measures were mainly due to a lack of demand savings for exterior lighting measures in ex-ante records, applying coincidence and waste heat factors to ex-post calculations. Reasons for differences amongst the refrigeration measures were driven by a lack of demand savings for some measures.
Total	80,417	75,325	94%	17.33	15.46	89%	

2. Evaluation Methods

The purpose of this report is to verify the actual PY8 gross and net program energy and demand savings estimates and compare them to the company's forecast and ex-ante estimates. The Evaluation Team conducted a variety of data collection and analytical methods to verify gross and net savings for each program. Given that many of the programs and measures were evaluated in PY6 or PY7, and that most programs did not change their design or measure-mix offered, PY8 evaluation efforts relied upon much of the recent evaluation efforts for In-service rates (ISRs) and net-to-gross (NTG) ratios. However, the Evaluation Team estimated new ISRs and NTGRs for select programs that changed design or did not have a recently evaluated value to apply. A high-level description of the evaluation methods is provided below.

- **Database Review Verification:** The Evaluation Team reviewed program-tracking databases to ensure that there were no duplicates or database errors and that DESC had accurately applied all agreed-upon PY8 deemed savings for each measure.
- **Engineering Desk Review & Analysis:** The Evaluation Team conducted a full engineering desk review of measures in PY1-PY7 evaluations. As a result, the Evaluation Team recommended the application of new deemed savings estimates for some measures prospectively in future program years. The team conducted this activity again in PY8 for select programs and measures. For example, the Appliance Recycling Program measure savings were evaluated based on the type of measures that were recycled in PY8. The Evaluation Team followed a new impact evaluation protocol for calculating recycled freezer savings based on the most recent update to the Uniform Methods Project (UMP). Heating and Cooling measure savings were also evaluated based on the baseline conditions, measure and household characteristics in PY8.
- **Project Desk Review:** The Evaluation Team conducted engineering desk reviews of a representative sample of the EWfYB projects. The Evaluation Team reviewed several sources of information to inform savings calculations, including post installation electric usage, and then applied the realization rate (RR) to the population of projects.
- **Application of Previous Evaluated Inputs:** The Evaluation Team and DESC determined where to focus evaluation funds in PY8 based on implementation costs, specific needs for each program and how the program was evaluated in previous years. As such, some of the previous evaluation findings were applied to PY8 savings. For example, ISRs for measures in the NEEP and SBES programs were developed in previous evaluations and were applied to the measure counts in PY8.
- **New ISRs and NTGR Research:** The Evaluation Team conducted surveys with representative samples of HEC participants, Heating & Cooling participants, Heating & Cooling participating contractors, and SBES refrigeration participants to develop revised ISRs and NTGRs.
- **Billing Analysis:** The Evaluation Team performed a pre-post billing data analysis for HER participants, using a comparison group, to develop revised ex-post savings per participant. The team also cross-referenced HER participants with other program-tracking data to make any adjustments for participation in other DESC programs.

Evaluation Methods

Table 5 shows the data collection and analytical methods the Evaluation Team applied for each program. This report contains a chapter for each program that provides more detailed data collection and analytical methods and even further details can be found in the Appendices. More rigorous evaluation methods were focused on new program components and measures in PY8 and on the EnergyWise for Your Business and Home Energy Report Programs given their savings contribution to the portfolio.

Table 5. Portfolio Evaluation Methods

Evaluation Method	ENERGY STAR® Lighting	Heating & Cooling	Neighborhood Energy Efficiency	Appliance Recycling	Home Energy Check-Up	Home Energy Reports	EnergyWise for Your Business	Small Business Energy Solutions
Reviewed Data-Tracking Systems against Deemed Savings and Corrected Tracking Errors	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Application of Previous Evaluated Findings (NTGR, Verification, Leakage, Savings per Participant and/or RRs)	Yes	Yes	Yes	Yes	Yes		Yes	Yes
Engineering Desk Review & Analysis	Yes	Yes	Yes	Yes	Yes		Yes	Yes
Project Desk Review							Yes	
Surveys for new ISR/NTGR		Yes			Yes			Yes
Billing Analysis						Yes		

3. Program-Specific Findings

3.1 ENERGY STAR® Lighting Program

3.1.1 Program Description

The ENERGY STAR® Lighting Program offers LEDs and advanced power strips through three channels, described below. PY8 was the fourth year of the EnergyWise Savings Store (Online Store) and Business Office Lighting (BOL) offerings, and the second year of the Low-Income Free LED Kits offering.

Online Store

The Online Store offers residential customers a range of standard and specialty LED products at discounted prices. Additionally, DESC introduced advanced power strips to the offering for the first time in PY8. Only customers with DESC electric service could purchase products through the Online Store, thus minimizing leakage to non-DESC customers. Customers had the option to purchase products offered online or over the phone and were limited to purchases of 15 bulbs per eligible customer account per year based on previous EM&V recommendations. Energy Federation Inc. (EFI) continued to implement the program in PY8. Program marketing included direct mail, bill inserts, online banner ads, news releases, cross-marketing through other DSM programs and promotions on the DESC website homepage and social media websites.

Business Office Lighting

In an effort to reach underserved customer segments, DESC offered free LED kits to customers who visited select DESC business offices across the DESC service area. The BOL LED kits consisted of five standard LEDs, including three 60-Watt equivalent bulbs, one 75-Watt equivalent bulb, and one 100-Watt equivalent bulb. Any DESC residential electric customers visiting the participating business offices during the promotional periods were eligible to receive one free kit per eligible residential account.

Low-Income Free LED Kits

In an effort to reach underserved low-income customer segments, DESC continued in PY8 to send postcards to targeted neighborhoods with a high proportion of low-income qualified customers based on U.S. Census data. The offer supplements the Neighborhood Energy Efficiency Program (NEEP), which has a hard time reaching these neighborhoods in a cost-effective manner. Recipients were invited to claim one free LED kit by requesting it online or via telephone using a promo code. Each kit contained five standard 60-Watt-equivalent LEDs.

3.1.2 Program Performance Summary

Table 6 shows the program performance summary. DESC exceeded its forecast for the number of units incentivized at less than half of its forecasted cost. Despite exceeding its sales forecast, the program achieved 72% of its gross energy savings forecast and 66% of its gross demand savings forecast, including carryover savings from installation of previous program years' sales that were not considered in the PY8 forecast. The lower-than-forecasted savings are primarily attributable to the application of an ISR for bulbs distributed during PY8 in combination with a small number of baseline wattage corrections for new measures incorporated into the Online Store during PY8.

Table 6. ENERGY STAR® Lighting Program Forecasts and Results

Metric	Forecast	Actual	% of Forecast Accomplished
Cost	\$1,348,630	\$581,763	43%
PY8 measure quantity	138,885	173,324	125%
Gross MWH savings	7,911	5,690	72%
Gross MW savings	0.79	0.52	66%
Net MWH savings	N/A	4,287	N/A
Net MW savings	N/A	0.39	N/A

3.1.3 Impact and Data-Tracking Findings

The Evaluation Team reviewed and verified program-tracking data and deemed savings values for accuracy and completed an engineering review to determine revised gross savings for new measures. The Evaluation Team then applied the ISR to revised savings estimates to determine ex-post gross savings and then component-specific NTGRs to estimate ex-post net savings. Finally, the Team incorporated ex-post gross and net carryover savings from measures sold during PY6 and PY7 and installed in PY8.

Table 7 provides a breakdown of energy and demand savings impacts in PY8. The Online Store was the core contributor to overall savings, accounting for 81% of ex-post gross savings from PY8 measures (i.e., before accounting for carryover savings from PY6 and PY7). Across the three components, the overall RR is 65% for gross energy savings and 70% for gross demand savings, before accounting for carryover savings. The application of ISRs accounts for most of the difference between ex-ante and ex-post savings, while the rest of the difference is attributable to the Evaluation Team's use of unrounded per-unit savings values and revised assumptions for five of the products newly introduced to the Online Store offering during PY8. With the addition of carryover savings from LED bulbs sold in previous years and installed during PY8, the RR is 83% for gross energy savings and 91% for gross demand savings.

Further, net savings account for 76% of ex-post gross savings overall for the program before incorporating carryover savings and 75% with carryover savings included. The Evaluation Team applied component-specific NTG ratios to calculate net savings, which is further described in the component specific sections below.

Program-Specific Findings

Table 7. ENERGY STAR® Lighting Program Ex-Post Gross and Net Savings Summary

Program Component	Verified Measure Quantity	Ex-Ante Gross Savings		Revised Gross Savings		Ex-Post Gross Savings		Gross Savings RR		Ex-Post Net Savings	
		MWH	MW	MWH	MW	MWH	MW	MWH	MW	MWH	MW
Online Store	141,184	5,507	0.46	5,505	0.50	3,554	0.33	65%	71%	2,594	0.24
Business Office Lighting	20,580	892	0.08	892	0.08	598	0.05	67%	70%	496	0.05
Low-Income Free LED Kits	11,560	418	0.03	418	0.04	255	0.02	61%	67%	242	0.02
PY8 First-Year Savings	173,324	6,817	0.57	6,815	0.62	4,406	0.40	65%	70%	3,333	0.31
Carryover Savings from PY6 Measures						721	0.07	N/A	N/A	532	0.05
Carryover Savings from PY7 Measures						562	0.05	N/A	N/A	422	0.04
Total PY8 Savings						5,690	0.52	83%	91%	4,287	0.39

Note: Some values in this table do not sum or divide exactly due to rounding.

Online Store Impacts

The Evaluation Team checked the tracking data for errors, such as duplicates and missing values, and reviewed deemed savings values for all measures.

Savings for the online store include over 141,000 LEDs of various wattages and 847 advanced power strips. The revised gross savings reflect the accurate quantities from the program-tracking data and updated per-unit savings for two new lighting measures and three new advanced power strip measures. To estimate revised gross savings for lighting measures, the Evaluation Team used halogen-equivalent baseline wattages for bulb types affected by EISA legislation and incandescent-equivalent baseline wattages for bulb types exempted from EISA legislation. To estimate revised gross savings for advanced power strips, the Team applied deemed savings values from the Illinois Technical Reference Manual (TRM) 7.0, which leverages research across a range of geographic areas and program delivery models. Please refer to Appendix B for more detail. To estimate ex-post savings, the Team applied an ISR of 64% for online store measures, which were calculated as part of the PY6 evaluation. Notably, the PY6 ISR estimate did not include advanced power strips, which are new to the program in PY8 and represent a very small percentage of savings (approximately 0.5%). As such, the Evaluation Team applied the 64% ISR assumption for advanced power strips. This assumption will need to be evaluated in future years should advanced power strips sales continue to grow.

Table 8 shows the resulting ex-post gross savings. The Online Store offering saved 3,554 MWH and 0.33 MW, resulting in a gross savings RR of 65% for energy savings and 71% for demand savings.

Table 8. Online Store Ex-Post Gross Savings Summary

Component	MWH	MW
Ex-Ante Gross Savings	5,507	0.46
Revised Gross Savings	5,505	0.50
(ISR)	64%	
Ex-Post Gross Savings	3,554	0.33
Gross Savings RR	65%	71%

Note: Some values in this table do not sum or divide exactly due to rounding.

Program-Specific Findings

The Evaluation Team applied a NTGR of 0.73 based on PY6 evaluation results to estimate PY8 Online Store ex-post net savings of 2,594 MWH and 0.24 MW. Table 9 displays PY8 ex-post gross and net savings for the Online Store.

Table 9. Online Store Ex-Post Net Savings Summary

Component	MWH	MW
Ex-Post Gross Savings	3,554	0.33
NTGR	0.73	
Ex-Post Net Savings	2,594	0.24

Business Office Lighting Impacts

Review of the BOL tracking data revealed that measure counts were accurate and complete. As part of the review, the Evaluation Team checked the data for duplicate participants and verified the absence of such records. After reviewing the tracking data, the Evaluation Team reviewed deemed savings estimates for the single LED product provided in each five-bulb kit and found that ex-ante per-unit savings were accurate and matched revised per-unit savings after rounding. The BOL offering exclusively distributed standard LEDs that are affected by EISA legislation, so the Evaluation Team assumed halogen-equivalent baseline wattages to estimate revised savings. The Team then applied the ISR of 67% based on PY6 evaluation results.

Table 10 shows the resulting ex-post gross savings. The BOL component saved 598 MWH and 0.05 MW, resulting in a gross savings RR of 67% for energy and 70% for demand savings.

Table 10. Business Office Lighting Ex-Post Gross Savings Summary

Component	MWH	MW
Ex-Ante Gross Savings	892	0.08
Revised Gross Savings	892	0.08
ISR	67%	
Ex-Post Gross Savings	598	0.05
Gross Savings RR	67%	70%

Note: Some values in this table do not sum or divide exactly due to rounding.

The Evaluation Team applied the deemed program-specific NTGR of 0.83 based on PY6 evaluation results to estimate PY8 BOL ex-post net savings of 496 MWH and 0.05 MW. Table 11 displays PY8 ex-post gross and net savings for the BOL component.

Table 11. Business Office Lighting Ex-Post Net Savings Summary

Component	MWH	MW
Ex-Post Gross Savings	598	0.05
NTGR	0.83	
Ex-Post Net Savings	496	0.05

Note: Some values in this table do not sum or divide exactly due to rounding.

Program-Specific Findings

Low-Income Free LED Kits Impacts

Review of the Low-Income Free LED Kits tracking data revealed that measure counts were accurate and complete. As part of the review, the Evaluation Team checked the data for duplicate participants and verified the absence of such records. After reviewing the tracking data, the Evaluation Team reviewed deemed savings estimates for the uniform five-bulb kit provided to each participant and found that ex-ante per-unit savings were accurate and matched revised per-unit savings after rounding. The Low-Income Free LED Kits offering exclusively distributed standard LEDs that are affected by EISA legislation, so the Team assumed a halogen-equivalent baseline wattage to estimate revised savings. The Evaluation Team then applied the ISR of 61%, based on PY7 evaluation results, to the revised savings estimates to determine ex-post gross savings.

Table 12 shows the resulting ex-post gross savings. The program saved 255 MWH and 0.02 MW, resulting in a gross savings RR of 61% for energy savings and 67% for demand savings.

Table 12. Low-Income Free LED Kits Ex-Post Gross Savings Summary

Component	MWH	MW
Ex-Ante Gross Savings	418	0.03
Revised Gross Savings	418	0.04
ISR	61%	
Ex-Post Gross Savings	255	0.02
Gross Savings RR	61%	67%

Note: Some values in this table do not sum or divide exactly due to rounding.

The Evaluation Team applied a NTGR of 0.95 based on PY7 evaluation results to estimate PY8 Low-Income Free LED Kits ex-post net savings of 242 MWH and 0.02 MW. Table 9 shows PY8 ex-post gross and net savings for the Low-Income Free LED Kits offering.

Table 13. Low-Income Free LEDs Kits Ex-Post Net Savings Summary

Component	MWH	MW
Ex-Post Gross Savings	255	0.02
NTGR	0.95	
Ex-Post Net Savings	242	0.02

Note: Some values in this table do not sum or divide exactly due to rounding.

Carryover Savings

In addition to the first-year savings from bulbs distributed in PY8, total ex-post savings also include savings from bulbs distributed in prior program years that were installed in PY8. Using the installation trajectory from the UMP, the Evaluation team estimated that PY6 and PY7 bulb sales contributed 1,087 MWH and 0.10 MW in ex-post net carryover savings (Table 14). Appendix B contains further detail on carryover savings calculations for PY8 and provides further detail on projected carryover savings for bulbs distributed in PY8 and in future years.

Table 14. ENERGY STAR® Lighting Program Carryover Savings Claimed in PY8

	Ex-Post Gross Savings		Ex-Post Net Savings	
	MWH	MW	MWH	MW
Carryover from PY6	721	0.07	532	0.05
Carryover from PY7	740	0.07	555	0.05
Total Carryover	1,461	0.13	1,087	0.10

Note: Some values in this table do not sum or divide exactly due to rounding.

3.2 Home Energy Reports Program

3.2.1 Program Description

The Home Energy Reports (HER) Program offers free monthly/bi-monthly reports to customers, comparing their energy usage over time to a peer group. The reports also provide information to help participants identify, analyze and act upon energy efficiency upgrade opportunities and energy saving behaviors to reduce their household energy usage. The initial HER is a customized report that provides participants with a summary of their household energy use and focuses on whole-house electricity usage. After the introductory four-page report, subsequent monthly/bimonthly Home Energy Updates compare the customers' usage to that of a peer group, promote a variety of customized energy efficiency tips, and provide information about other DESC EnergyWise programs.

The HER Program offers three different treatment options, including a mailed paper report, an emailed report, and an e-mailed report in combination with an online portal. Customers using the online portal have the option to create a Custom Action Plan, wherein they can develop personalized energy efficiency forecasts.

DESC program staff use an 'opt-in' model to recruit customers into the HER program. The implementer, Direct Options, purchases demographic data that corresponds with DESC's customer base and uses this data to select specific customers to target for program enrollment. Direct Options targets customers with characteristics that are likely to achieve higher savings such as high income and high rates of energy use. The number of invitations per year is dependent on attrition from the previous program year.

To enroll, DESC invites customers to complete an initial Home Energy Survey and set an energy savings goal. The Home Energy Survey asks details about their home, household appliances, and equipment. Once complete, respondents receive the HER reports. If a customer no longer wants to receive the reports, they can cancel the reports online or contact an DESC customer representative. This opt-in model is distinct from other HER programs implemented across the country, as most are offered as an 'opt-out' model, where customers are defaulted into the program and continue to receive reports for years.

3.2.2 Program Performance Summary

As shown in Table 15, the program exceeded its participation forecasts while spending less than it forecasted. However, the program fell short of its energy and demand savings forecasts, primarily due to PY8 evaluation results that showed participants, on average, are reducing 0.41% of their annual electric usage instead of the forecasted 1.05%.

Table 15. HER Program Forecasts and Results

Metric	Forecast	Actual	% of Forecast Accomplished
Cost	\$753,127	\$537,725	71%
Participants (Treatment Households)	42,221	42,197	100%
Net MWH Savings	15,254	2,705	18%
Net MW Savings	5.97	0.96	16%

Note: Some values in this table do not sum or divide exactly due to rounding

3.2.3 Impact and Data-Tracking Findings

To determine the program's energy savings, the Evaluation Team estimated per-household savings by conducting an energy usage analysis which compared energy usage from program participants to similar non-participants. This approach employed an industry standard method, which matches participants with non-participant customers who are similar in terms of energy usage and other factors. The Evaluation Team tested a number of models, confirming similar results across model specifications, and ultimately selected a lagged dependent variable (LDV) model to estimate net program energy savings. Next, the Evaluation Team conducted a channeling analysis to avoid double-counting savings achieved through other DESC programs. For detailed impact estimation methods, please see Appendix I.

As part of the ex-post analysis for PY8, the Evaluation Team reviewed the program-tracking databases from DESC and Direct Options and found several data tracking errors, resulting in the net removal of 130 participants from ex-post participation counts:

- 142 customers were marked as inactive in Direct Options' data but marked as active in DESC's data. DESC reviewed these records and determined that a sample of these customers had not received reports since 2016, thus the Evaluation Team removed these participants from the participant count.
- One customer was removed from the participant count because they were labeled as both treatment and control in Direct Options' data.
- 13 customers were erroneously removed from DESC's ex-ante participant counts. These customers had already been removed due to exiting the program prior to PY7. However, DESC's ex-ante counts removed them again in PY8, resulting in them being erroneously removed twice. Correcting this error increased PY8 participation counts by 13.

After confirming the number of participating households, the Evaluation Team determined ex-post net savings for the program by applying the average annual savings per-household to the 42,197 verified active PY8 participants. This average annual savings value accounts for prorated savings for customers who either left the program or enrolled in the program in mid-PY8. Whereas most participants receive 365 days of savings credit, these prorated customers only received savings credit for the days they were participants. Table 16 breaks out the verified active participants by those who received prorated savings adjustments versus full-year savings. Notably, DESC removed a number of customers in mid-PY8 whom the Evaluation Team had identified as "negative savers" based on PY7 evaluation results. DESC verified that these customers were not opening their web links to view their reports before removing them from the program.

Program-Specific Findings

Table 16. HER Participant Counts for Ex-Post Net Savings Calculations

Program Participants	Ex-Post
Total Active PY8 Participants (A)	42,197
Final Bill (B)	2,661
Opt-Out (C)	374
Negative Saver Removed (D)	1,752
Early Finish (E=B+C+D)	4,787
Enrolled Mid-PY8 (F)	3,817
Participants with Prorated Savings (G =E=F)	8,604
Participants with Annual Savings (A-G)	33,593

The PY8 program achieved ex-post net savings of 0.41% of household consumption, or 64.11 KWH and 0.02 KW per household. Applying these values to each treatment household resulted in 2,705 MWH and 0.96 MW in total. Table 17 shows ex-post net savings compared to ex-ante. The RR for the program was 0.41 for MWH savings and MW savings. The RR reflects that the PY8 consumption analysis detected less than half of the savings assumed by ex-ante based on PY6 evaluation results.

Table 17. HER Ex-Post Net Savings Summary

HER Program	Ex-Ante	Ex-Post	RR
Total Treatment Households	42,327	42,197	N/A
Net Adjusted Savings			
Adjusted % Savings per Household	1.05%	0.41%	N/A
Average Adjusted Annual Savings per Household (KWH)	157.47	64.11	0.41
Average Annual Savings per Household (KW)	0.06	0.02	0.41
Total Program Savings			
Program Savings, All Households (MWH)	6,665	2,705	0.41
Program Savings, All Households (MW)	2.37	0.96	0.41

3.3 Heating & Cooling Program

3.3.1 Program Description

The Heating & Cooling Program offers rebates to DESC residential electric customers for installing high-efficiency air conditioners (ACs) and heat pumps (HPs) and improving ductwork. The program's primary goal is to assist customers with reducing electric consumption without compromising comfort in the home. To participate in the program, a customer must receive residential electric service from DESC in an existing separately metered residence.

Heating & Cooling Equipment rebates are the largest component of the program and help offset the upfront cost for purchases of energy-efficient ENERGY STAR®-qualified HVAC units. The rebates vary according to HVAC type and efficiency level of the installed equipment. Notably, the program made significant changes to the HVAC rebate levels in mid-PY8 based on feedback from contractors, increasing rebates for AC and HP units. Table 18 summarizes the rebates offered to customers before and after the rebate change.

Program-Specific Findings

Table 18. Heating & Cooling Program PY8 Program Measures and Rebate Amounts

Equipment Type	Minimum Efficiency Requirements	Rebate Amount	
		Pre April 2 nd , 2018	Post April 2 nd , 2018
Packaged Central Air Conditioner (CAC), Air-Source Heat Pump (ASHP) and Dual Fuel Heat Pump (DFHP)	15 SEER and 12 EER (and 8.2 HSPF for heat pumps)	\$200	\$300
	CAC: ≥ 16 SEER ^a and ≥ 12.5 EER ASHP: ≥ 16 SEER ^a and ≥ 12.2 EER and ≥ 8.3 HSPF	\$400	\$500
Split CAC, ASHP and DFHP	15 SEER and 12.5 EER (and 8.5 HSPF for heat pumps)	\$200	\$300
	≥ 16 SEER ^a and ≥ 13 EER (and ≥ 9 HSPF for heat pumps)	\$400	\$500
Duct Sealing	Duct leakage must be a 50% improvement of the existing duct leakage rate or 150 CFM reduction in leakage	\$150	
Duct Insulation	Minimum insulation $\geq R-8$	\$150	
Complete Duct Replacement	Total leakage must be 10% or less	\$300	

Notes: SEER: Seasonal Energy Efficiency Rating; EER: Energy Efficiency Rating; HSPF: Heating Seasonal Performance Factor; CFM: Cubic Feet per Minute.

a. The minimum efficiency requirement pre-rebate change was ≥ 17 SEER.

3.3.1 Program Performance Summary

In PY8, the program reported 4,692 participants who in total installed 4,452 Heating & Cooling Equipment and 678 Ductwork measures. The program achieved nearly 100% of the planned participation, though program spending was 151% of the budget in part due to the increased incentive amounts. The program achieved 4,427 MWH of ex-post gross energy savings and 3.18 MW of ex-post gross demand savings. While the ex-ante to ex-post RRs for this program are approximately 100% in PY8, the program nearly tripled its savings forecasts. Table 19 summarizes the PY8 forecasts and overall results for the program in terms of cost, participation, and energy and demand savings.

Table 19. Heating and Cooling Program Forecasts and Results

Metric	Forecast	Actual	% of Forecast Accomplished
Cost	\$1,471,466	\$2,223,281	151%
Measures	5,150	5,130	100%
Gross MWH Savings	1,542	4,427	287%
Gross MW Savings	1.09	3.18	291%
Net MWH Savings	N/A	2,892	N/A
Net MW Savings	N/A	1.96	N/A

Note: Some values in this table do not sum or divide exactly due to rounding.

ASHPs account for more than half (61%) of all rebated PY8 measures, followed by CACs (26%), then complete duct replacements (9%). Table 20 summarizes the total number of installed PY8 measures.

Program-Specific Findings

Table 20. Heating & Cooling Program Number of Measures Rebated

Measure Type		Total Ex-Post PY8 Measures
Heating & Cooling Equipment	ASHPs	3,106
	CACs	1,329
	DFHPs	17
	Total HVAC	4,452
Ductwork	Complete Duct Replacements	440
	Duct Insulation	211
	Duct Sealing	27
	Total Ductwork	678
Total Program Measures		5,130

Heating & Cooling Equipment was the largest component of the program for both energy savings (83%) and measures rebated (87%). Table 21 shows the total PY8 ex-post gross savings by program component.

Table 21. Heating and Cooling Program Population Size

Program Component	Ex-Post Gross Savings (MWH)	Ex-Post Gross Savings (MW)
Heating & Cooling Equipment	3,674	2.93
Ductwork	753	0.25
Total	4,427	3.18

3.3.2 Impact and Data-Tracking Findings

As shown in Table 22, the overall RR for the program was 101% for MWH and 100% for MW savings. Although the Evaluation Team identified slight differences in energy savings assumptions, the impact on overall program savings was minimal (1%). The Evaluation Team applied newly calculated NTGRs for PY8 Heating & Cooling Equipment and PY3 evaluated values for Ductwork to calculate the total program net savings of 2,892 MWH and 1.96 MW.

Table 22. Heating and Cooling Program Ex-Post Gross Savings Summary

Program Component	Ex-Ante Gross Savings		Ex-Post Gross Savings		RR		NTGR		Ex-Post Net Savings	
	MWH	MW	MWH	MW	MWH	MW	MWH	MW	MWH	MW
Heating & Cooling Equipment	3,649	2.92	3,674	2.93	101%	100%	0.66	0.62	2,432	1.80
Ductwork	753	0.25	753	0.25	100%	100%	0.61	0.62	460	0.15
Total	4,402	3.17	4,427	3.18	101%	100%	0.65	0.62	2,892	1.96

Note: Some values in this table do not sum or divide exactly due to rounding.

The following sections provide detailed impact findings for each program component.

Heating & Cooling Equipment Impact Findings

The Evaluation Team reviewed the program-tracking database to verify the total number of rebated measures. The Evaluation Team found no duplicate records or database errors within the program-tracking database.

Program-Specific Findings

and, therefore, did not adjust ex-ante measure quantities. Table 23 shows the resulting verified ex-post measure quantity is equal to the ex-ante measure quantity.

Table 23. Heating & Cooling Equipment Number of Measures Rebated

Measure	Ex-Ante Quantity	Verification Rate	Ex-Post Quantity
ASHP	3,106	100%	3,106
Central AC	1,329	100%	1,329
DFHP	17	100%	17
Total	4,452	100%	4,452

The Evaluation Team developed per-ton deemed savings values as part of the PY6 and PY7 evaluation to apply in PY8. Both ex-ante and ex-post savings calculations applied these values to determine overall PY8 savings for Heating & Cooling Equipment measures. The Evaluation Team verified that DESC applied the correct deemed values, except for cases where the deemed value was unavailable for a new measure. In these cases, DESC applied the deemed savings value that most closely aligned with the measure type and efficiency in their data tracking records (e.g., applied per-ton deemed savings for a 27 SEER ASHP to a 29 SEER ASHP). The Evaluation Team calculated and applied a new deemed savings value for these cases as part of the ex-post analysis. In most cases, ex-ante estimates used a deemed savings value for a lower efficiency unit than the actual installed efficiency, which understated savings and resulted in slightly higher ex-post energy savings. Appendix C summarizes the PY8 deemed savings values for all Heating & Cooling Equipment measures.

Overall, the PY8 Heating & Cooling Equipment component achieved ex-post gross savings of 3,674 MWH and 2.93 MW. The RRs for energy and demand are 101% and 100%, respectively. Table 24 compares the total ex-ante and ex-post gross savings by equipment type.

Table 24. Heating & Cooling Equipment Ex-Post Gross Savings Summary

Measure Type	Ex-Ante Gross Savings		Ex-Post Gross Savings		Gross RR	
	MWH	MW	MWH	MW	MWH	MW
ASHP	3,037	2.41	3,057	2.42	101%	100%
Central AC	595	0.50	599	0.50	101%	100%
DFHP	18	0.01	18	0.01	100%	98%
Total	3,649	2.92	3,674	2.93	101%	100%

Note: Some values in this table do not sum or divide exactly due to rounding.

To calculate ex-post net savings, the Evaluation Team applied a weighted average NTGR of 0.66 for energy savings and 0.62 for demand savings. To account for the mid-year rebate change, the Evaluation Team applied two NTGRs. The Evaluation Team applied the PY6 NTGR to projects completed before the rebate change. For projects completed after the rebate change, the Team calculated a new NTGR using PY8 participant and contractor survey results. The team then weighted the two NTGRs by the proportion of total ex-post gross savings they represent to establish an overall NTGR for PY8. Table 25 shows the final weighted NTGR for PY8. For PY9, the Evaluation Team recommends the post-rebate change NTGRs (0.72 for KWH and 0.68 for KW) as they align with the new incentive structure.

Program-Specific Findings

Table 25. Heating & Cooling Equipment NTGRs

Measure	Ex-Post Gross Savings		NTGR	
	KWH	KW	KWH	KW
Pre-Rebate Change	143,528	115	0.55	0.48
Post-Rebate Change	291,328	234	0.72	0.68
Overall for PY8 (Weighted)	434,856	349	0.66	0.62

In PY8, the Heating & Cooling Equipment component achieved ex-post net savings of 2,432 MWH and 1.80 MW. Table 26 summarizes the total net impacts by equipment type.

Table 26. Heating & Cooling Equipment Ex-Post Net Savings Summary

Measure Type	Ex-Post Gross Savings		NTGR		Ex-Post Net Savings	
	MWH	MW	MWH	MW	MWH	MW
ASHP	3,057	2.42	0.66	0.62	2,024	1.49
Central AC	599	0.50			397	0.31
DFHP	18	0.01			12	0.008
Total	3,674	2.93	0.66	0.62	2,432	1.80

Note: Some values in this table do not sum or divide exactly due to rounding.

Ductwork Impact Findings

The Evaluation Team reviewed the program-tracking database to verify the total number of rebated measures. The Evaluation Team found no duplicate records or database errors within the program-tracking database and, therefore, did not adjust ex-ante measure quantities. Table 27 shows the resulting verified ex-post measure quantity is equal to the ex-ante measure quantity.

Table 27. Ductwork Number of Measures Rebated

Measure	Ex-Ante Quantity	Verification Rate	Ex-Post Quantity
Complete Duct Replacement	440	100%	440
Duct Insulation	211	100%	211
Duct Sealing	27	100%	27
Total	678	100%	678

Ductwork deemed savings values are applied per-ton of HVAC capacity. There were 85 (13%) Ductwork measures where the HVAC tonnage is unknown. The Evaluation Team calculated and applied a nominal average of 3.0 tons to these records using program-tracking data from PY5 to PY8. While there are differences in ex-ante and ex-post assumptions for measures with unknown tonnage, the impact on savings is minimal (<0.3%). Table 28 compares the total ex-ante and ex-post tons by measure type.

Program-Specific Findings

Table 28. Ductwork Ex-Ante and Ex-Post Total Capacity (Tons) Comparison

Measure	Ex-Ante Capacity (Tons)	Ex-Post Capacity (Tons)	% Change
Complete Duct Replacement	1,299	1,296	-0.22%
Duct Insulation	619	617	-0.40%
Duct Sealing	88	88	-0.25%
Total	2,006	2,001	-0.28%

Note: Some values in this table do not sum or divide exactly due to rounding.

Both ex-ante and ex-post savings calculations applied the per-ton deemed savings values established in PY5 to determine overall PY8 savings for Ductwork measures. The Evaluation Team verified that ex-ante savings applied the correct deemed values for all program measures. PY8 deemed savings values for all ductwork measures are provided in Appendix C.

PY8 Ductwork measures achieved total ex-post gross savings of 753 MWH and 0.25 MW. Table 29 summarizes the total ex-ante and ex-post gross savings by equipment type. The slight differences between ex-ante and ex-post savings are driven by the assumptions for measures with unknown tonnage. However, these differences had no impact on the overall Ductwork savings, which achieved realizations rates of 100% for both MWH and MW.

Table 29. Ductwork Ex-Post Gross Savings Summary

Measure Type (and HVAC System Type)	Ex-Ante Gross Savings		Ex-Post Gross Savings		Gross RR	
	MWH	MW	MWH	MW	MWH	MW
Complete Duct Replacement (HP)	388	0.10	387	0.10	100%	100%
Complete Duct Replacement (AC)	228	0.11	227	0.11	100%	100%
Duct Insulation (HP)	75	0.02	76	0.02	102%	102%
Duct Insulation (AC)	37	0.02	37	0.02	101%	101%
Duct Sealing (HP)	16	0.005	16	0.005	99%	99%
Duct Sealing (AC)	9	0.004	9	0.004	103%	103%
Total	753	0.25	753	0.25	100%	100%

Note: Some values in this table do not sum or divide exactly due to rounding.

The Evaluation Team applied self-reported NTGRs from PY3 evaluation results to the PY8 ex-post gross savings values to determine ex-post net savings. As shown in Table 30, the program achieved ex-post net savings of 460 MWH and 0.15 MW.

Table 30. Ductwork Ex-Post Net Savings Summary

Measure Type (and HVAC System Type)	Ex-Post Gross Savings		NTGR		Ex-Post Net Savings	
	MWH	MW	MWH	MW	MWH	MW
Complete Duct Replacement (HP)	387	0.10	0.61	0.62	236	0.06
Complete Duct Replacement (AC)	227	0.11			139	0.07
Duct Insulation (HP)	76	0.02			47	0.01
Duct Insulation (AC)	37	0.02			23	0.01
Duct Sealing (HP)	16	0.005			10	0.003
Duct Sealing (AC)	9	0.004			6	0.003
Total	753	0.25	0.61	0.62	460	0.15

Note: Totals may not sum or multiply precisely due to rounding.

3.4 Home Energy Check-Up Program

3.4.1 Program Description

The Home Energy Check-up (HEC) Program provides electric customers in DESC's service territory with a home visit that includes a visual inspection of the home and an energy consultation with the customer. During the check-up, an DESC representative, who is certified as a Building Analyst Professional through the Building Performance Institute (BPI), identifies sources of high energy use, reviews up to two years of consumption data and weather impacts, and discusses energy-saving behaviors with the customer (e.g., thermostat settings, water heater settings, etc.). In addition, they provide the customer with free ("leave-behind") measures (Table 31) and a list of recommended energy conservation actions ("recommended measures") (Table 32). In mid-PY7, DESC discontinued its offering of a lighting kit with four CFLs and one LED and transitioned to a kit that includes five LED bulbs. Also beginning in mid-PY7, DESC provided direct installation of kitchen faucet aerators for a subset of HEC participants and updated the recommended measures list to suggest replacing lights with ENERGY STAR® LEDs instead of CFLs.

Table 31. HEC Leave-behind Measures

Leave-behind Measure
Kit of five LED bulbs (three 10-Watt, one 12-Watt, and one 14-Watt)
Hot water pipe insulation (6 feet), as appropriate
Electric water heater insulating blanket, as appropriate
Kitchen Faucet Aerator (direct install), as appropriate

Note: measures were leave-behind except where noted

Table 32. HEC Energy Conservation Actions Recommended during the Visit

Recommended Measure
Set thermostat at 68° F or lower in the winter and 78° F or higher in the summer
Install a smart thermostat
Replace air filters
Leave interior doors open and keep vents open for adequate air flow
Repair ducts
Have central heating and cooling system serviced

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Recommended Measure
Upgrade attic insulation to a minimum of R-38
Caulk, seal and weather-strip windows or doors
Adjust water heater temperature to 120 °F
Replace incandescent lamps with ENERGY STAR® LEDs
Unplug appliances, lights, TVs, computers, etc. when not in use

Note: Program materials further recommend visiting DESC's website or calling DESC. Information about Heating and Cooling Rebates, the Appliance Recycling Program and the EnergyWise Savings Store was also included in the leave-behind materials.

3.4.2 Program Performance Summary

In PY8, the program exceeded participation targets, but fell short of its energy and demand savings goals due to lower per-participant savings than forecasted. Table 33 summarizes the forecasts and actuals in terms of costs, participation and energy and demand savings.

Table 33. HEC Forecasts and Results

Metric	Forecast	Actual	% of Forecast Accomplished
Costs	\$829,130	\$804,886	97%
Participants	3,361	3,460	103%
Gross MWH	2,242	1,866	83%
Gross MW	0.46	0.26	56%
Net MWH	N/A	1,309	N/A
Net MW	N/A	0.20	N/A

Note: Some values in this table do not sum or divide exactly due to rounding.

The program performed check-ups for 3,460 residential customers during PY8. Almost all participants received the lighting kit with five LEDs (99%), with the other measures being less prevalent. A small portion of participants (21 or <1%) received a check-up but did not receive any leave-behind measures. Table 34 summarizes program participation by each of the measures offered through HEC.

Table 34. HEC Participation by Leave-behind Measure

Measure	Number of Participants Who Received Measure	% of Total Participants (n=3,460)	Total Measures Provided in PY8
LEDs	3,439	99%	17,195 bulbs
Kitchen Faucet Aerator	459	13%	459 aerators
Hot Water Pipe Insulation	537	16%	3,222 feet
Electric Water Heater Insulating Blanket	624	18%	624 blankets

Note: Measure totals do not sum to 3,460 because participants were given multiple measures.

3.4.3 Impact and Data-Tracking Findings

The impact evaluation included multiple steps. First, the Evaluation Team reviewed the program-tracking database for accuracy. Next, the team determined ex-post gross saving by applying ISRs to leave-behind measure quantities and a per-participant recommended measure savings value, both derived from the PY8

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participant survey. The team determined ex-post net savings by applying NTGRs, also derived from the PY8 participant survey, to ex-post gross savings. Last, the team applied carryover savings from lighting measures distributed in previous years but installed in PY8. The next sections provide detail on each of these steps.

Program-Tracking Database Review

The Evaluation Team reviewed the program-tracking database to verify the total number of leave-behind or installed measures. The Evaluation Team noted a minor discrepancy in the program-tracking database. Specifically, two customers who received a follow-up visit after their initial Home Energy Check-up were counted as having two separate visits each. This discrepancy reduced the number of check-ups by two. Further, one customer's visit was completed in late November, but the project was closed in early December. As a result, the program-tracking data claimed savings for one additional check-up compared to what was initially reported to the Commission (this included one LED kit the participant received during their home visit). Taken together, the two discrepancies resulted in one less participant but one additional LED Kit. Next, the Evaluation Team applied ISRs to ex-ante measure quantities to determine ex-post measure quantities. ISRs are based on PY8 survey results (see Appendix D for more detail.) Table 35 shows the number of measures tracked in the program database and verified as installed.

Table 35. HEC Leave-behind Measure Verification

Measure	Ex-Ante Measure Quantity	Verification Rate	Verified Measure Quantity	ISR	Ex-Post Measure Quantity	Unit
LEDs	17,190	100%	17,195	74%	12,651	Bulbs
Kitchen Faucet Aerators	459	100%	459	98%	448	Aerators
Hot Water Pipe Insulation	537	100%	537	70%	376	6-foot packs
Electric Water Heater Insulating Blanket	624	100%	624	61%	380	Blankets

Note: Some values in this table do not sum or divide exactly due to rounding.

Ex-Post Gross Savings for PY8 Participants

To calculate ex-post gross savings, the Evaluation Team applied deemed savings values to ex-post measure quantities. As shown in Table 36, the program achieved ex-post gross savings of 1,786 MWH and 0.25 MW from PY8 participants, compared to 2,218 MWH and 0.36 MW in PY7. The primary driver of this difference is a reduction in recommended measure savings per household based on PY8 survey results. Note that the total PY8 claimed savings for this program are higher than what is shown in the table below because the evaluation accounted for PY5, PY6 and PY7 carryover savings (see Table 40). More detail on the calculation of ex-post gross savings is provided following the table.

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Table 36. HEC Ex-Post Gross Savings by Measure Type

Program Component	Ex-Post Measure Quantity	Unit	Savings per Unit		Ex-Post Gross Savings	
			KWH	KW	MWH	MW
LEDs	12,651	Bulbs	43.36 ^a	0.004 ^a	549	0.05
Faucet Aerators	448	Aerators	225.00	0.011	101	0.005
Hot Water Pipe Insulation	376	6-foot packs	82.30	0.009	31	0.004
Electric Water Heater Insulating Blanket	380	Blankets	360.80	0.041	137	0.02
Recommended Measures	3460	Household	280.06	0.05	969	0.18
Total					1,786	0.25

Note: Some values in this table do not sum or divide exactly due to rounding.

a. Per bulb savings for LED is weighted average of various wattage bulbs in LED kit

LEDs

There were 3,439 customers who received a kit of five low-wattage LED bulbs (ranging in wattages) for a total of 17,195 bulbs. The PY8 participant survey found that respondents installed 74% of the LEDs. The Evaluation Team applied this ISR to determine that the ex-post quantity installed was 12,651, which led to ex-post gross savings of 549 MWH and 0.05 MW.

Faucet Aerators

The program provided direct installation of kitchen faucet aerators to 459 customers. The PY8 participant survey found that 98% of respondents' faucet aerators remained installed. The Evaluation Team applied this ISR to determine that the ex-post quantity installed was 448 faucet aerators, which led to ex-post gross savings of 101 MWH and 0.005 MW.

Hot Water Pipe Insulation

There were 537 customers with electric water heaters and uninsulated hot water pipes that received six feet of hot water pipe insulation, for a total of 3,222 feet of hot water pipe insulation. The PY8 participant survey found that respondents installed 69% of all pipe insulation received. The Evaluation Team applied this ISR to determine that the ex-post quantity installed was 376 6-foot packs (or 2,256 feet), which led to ex-post gross savings of 31 MWH and 0.004 MW.

Electric Water Heater Insulating Blanket

There were 624 customers with electric water heaters that received water heater insulating blankets through the program. The PY8 participant survey found that respondents installed 61% of all blankets received. The Evaluation Team applied this ISR to determine that the ex-post quantity installed was 380 blankets, which led to ex-post gross savings of 137 MWH and 0.0 MW.

Recommended Measures

All 3,460 program participants received a list of recommended measures. The Evaluation Team established per-participant savings of 280 KWH and 0.05 KW from recommended measures based on PY8 survey findings. Applying the per-participant value to each participant resulted in total ex-post gross savings for recommended measures of 969 MWH and 0.18 MW, compared to 1,626 MWH and 0.31 MW in PY7.

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Table 37 provides an overview of the total gross savings and per-participant savings for the recommended measures. The main driver of recommended measure savings was duct work repair (33% of KWH savings), programmable or smart thermostats (28% of KWH savings) and installing additional LEDs (15% of KWH savings). See Appendix D for detailed per-participant recommended measure savings calculations.

Table 37. HEC Recommended Measure Gross Savings Overview

Recommended Measure	Number of Participants Who Completed Measure	Total Ex-Post Gross Savings from Measure		Ex-Post Gross Savings per Participant	
		KWH	KW	KWH	KW
Repair ducts	94	45,518	16.00	484.24	0.17
Install programmable thermostat	58	38,543	-10.58	664.53	-0.18
Install LEDs	60	20,806	1.38	346.77	0.02
Caulk, seal and weather-strip windows or doors	115	12,613	3.27	109.68	0.03
Have central heating and cooling system serviced	89	11,408	11.88	128.18	0.13
Attic Insulation	41	4,775	2.60	116.45	0.06
Adjust water heater temperature to 120 °F	30	3,415	0.39	113.84	0.01
Replace air filters	41	2,112	0.66	51.51	0.02
Total	N/A	139,191	25.59	280.06^a	0.05^a

a. Total ex-post gross savings per-participant is the total ex-post gross savings divided by the number of surveyed participants (n=497). Note: Some values in this table do not sum or divide exactly due to rounding.

Program Ex-Post Gross Savings Summary

The program achieved ex-post gross savings of 1,786 MWH and 0.25 MW resulting in RRs of 0.57 for MWH and 0.43 for MW savings, as shown in Table 38. Two key factors drive the RRs.

- DESC used a deemed savings value of 907 KWH and 0.17 KW per participant, which did not align with the Evaluation Team's recommend values from PY7 (766 KWH and 0.13 KW).
- The recommended measure per-household savings decreased by approximately 50% in PY8 (280 KWH and 0.05 KW) compared to the per-household savings value calculated in PY6 (573 KWH and 0.11 KW). While 80% (401 of the 497 surveyed participants) of the surveyed PY8 participants indicated performing at least one of the recommended measures, which is a 10% increase from survey results in PY6, the Evaluation Team found that PY8 participants installed fewer measures on average compared to PY6. In PY8, surveyed participants installed on average 2.67 recommended measures (n=497) per household compared to 7.30 in PY6 (n=273).

Table 38. HEC Ex-Post Gross Savings Summary (Before Carryover Savings)

Ex-Ante Gross Savings		Ex-Post Gross Savings		RR	
MWH	MW	MWH	MW	MWH	MW
3,139	0.59	1,786	0.25	0.57	0.43

Note: Some values in this table do not sum or divide exactly due to rounding.

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Net Verified Savings for PY8 Participants

The Evaluation Team applied NTGRs of 0.70 (MWH) and 0.77 (MW) to the total ex-post gross savings to arrive at the total program ex-post net savings. The PY8 NTGRs are based on PY8 evaluation results and more detail is provided in Appendix D. Table 39 summarizes the total net savings for PY8 participants. The program achieved ex-post net savings of 1,247 MWH and 0.19 MW.

Table 39. HEC Ex-Post Net Savings Summary

Ex-Post Gross Savings		NTG Ratio		Net Savings	
MWH	MW	MWH	MW	MWH	MW
1,786	0.25	0.70	0.77	1,247	0.19

Note: Some values in this table do not sum or divide exactly due to rounding.

Total Net Savings to Claim in PY8

Total net savings that can be claimed in PY8 are slightly higher than savings only from PY8 participants, as it also includes savings from leave-behind CFLs and LEDs from prior program years that were installed in PY8. Using assumptions from the UMP, the Evaluation Team estimated that 1,749 CFLs from PY5, PY6 or PY7 and 530 LEDs from PY6 or PY7 were installed in PY8. As shown in Table 40, this resulted in 62 MWH and 0.005 MW of additional net savings. See Appendix D for more detailed carryover savings calculations.

Table 40. HEC Total Savings Claimed in PY8

Program Year	Gross Savings		Net Savings ^a	
	MWH	MW	MWH	MW
Ex-Ante PY8 (A)	3,139	0.59	2,480	0.44
Ex-Post Total Carryover Savings Claimed in PY8 (B)	80	0.007	62	0.005
Ex-Post PY8 Participants (C)	1,786	0.25	1,247	0.19
Total Ex-Post Savings Claim for PY8 (B+C=D)	1,866	0.26	1,309	0.20
Gross RR (D/A)	0.59	0.44	N/A	N/A

a. Net savings take into account the PY5 NTGR for PY5 leave-behind CFLs (0.68 for electric energy savings and 0.78 for demand savings) as well as the PY6 NTGR for PY6 and PY7 leave-behind CFLs and LEDs (0.79 for electric energy savings and 0.74 for demand savings)

3.5 Neighborhood Energy Efficiency Program

3.5.1 Program Description

The Neighborhood Energy Efficiency Program (NEEP) provides income-qualified residential customers with an in-home energy assessment of their home and low-cost energy-saving measures at no cost to the customer. DESC delivers the program using a neighborhood door-to-door sweep approach and directly installs a variety of energy efficiency measures for customers. DESC delivers the program to neighborhoods where approximately half of the households have income levels equal to or less than 150% of the 2012 poverty guideline, as defined by the federal government. Honeywell assisted DESC as the program implementer providing in-home services to customers.

During the home visits, the DESC representative conducts a walkthrough of the home and makes recommendations for additional ways to save energy. Depending on their needs, participants received various measures (see “Core” measures in Table 41). The program also continued to offer the “Mobile Home” measure

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component that was first introduced in PY6. Table 41 lists the measures provided through the program. Notably, most mobile home customers (91 of 100) received Core measures as well as Mobile Home component measures.

Table 41. NEEP Measures

Measure/Action	
Core Program Measures	Mobile Home Measures/Offering
LEDs (various wattages)	Air Sealing (various levels of leakage reduction)
HVAC Filters (various sizes)	Attic Plug & Fill Insulation (> R-30)
Smart-Strips	Belly Board Insulation (> R-19)
Water Heater Pipe Wraps (1 foot)	Belly Board Repair
Water Heater Blankets	Digital Switch Plate Wall Thermometer
Kitchen Faucet Aerators	Duct Sealing with > 10% Reduction
Water Heater Temperature Adjustment	Programmable Communicating Thermostat
	Reflective Roof Coating
	Wi-Fi Enabled Thermostat

Customers also receive a list of tips for saving energy, which encourages them to take additional energy conservation actions following the representative's visit, and a checklist of installed measures detailing the benefits of each measure added to their home.

3.5.2 Program Performance Summary

The program performed well in PY8, spending roughly 40% more than initially budgeted but exceeding participation, energy, and demand savings forecasts. The program exceeded savings forecasts mainly because DESC exceeded its participation forecast. Table 42 summarizes the forecasted and actual results in terms of costs, participation and energy and demand savings.

Table 42. NEEP Forecasts and Results

Metric	Forecast	Actual	% of Forecast Accomplished
Cost	\$991,200	\$1,391,090	140%
Participants	2,200	3,586	163%
Gross MWH Savings	2,217	4,090	185%
Gross MW Savings	0.36	0.41	115%
Net MWH Savings	N/A	4,090	N/A
Net MW Savings	N/A	0.41	N/A

Note: Some values in this table do not sum or divide exactly due to rounding.

The program performed in-home energy assessments for 3,586 residential customers. The majority (3,577) received Core measures while 100 customers also received weatherization measures targeted to mobile homes.

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Table 43: NEEP Participation by Program Type

Program Component	Number of Participants	% of Total Participants
Core Program - Direct install measures	3,486	97%
Mobile home weatherization + direct install	91	3%
Mobile home weatherization only	9	0.3%
Total Program Participants	3,586	100%

Note: Some values in this table do not sum or divide exactly due to rounding.

The program offered seven different Core program measures to customers, with the three most common measures being LEDs, kitchen faucet aerators and smart-strips. DESC chose which measures to install based on customer need and, on average, customers received four of the seven available measures. Further, the program offered nine different Mobile Home measures, with the three most common measures being digital switch plate wall thermometers, duct sealing and air sealing. On average, mobile home customers received approximately four of the nine available measures. Table 44 presents measure quantities and the number of customers broken out by Core and Mobile Home measures.

Table 44. NEEP Number of Measures Given

Measure	Ex-Post Program Participants	% of Total Participants	Total Measures Given in PY8 ^a	Unit
Core Program Measures (N=3,577 customers)				
LEDs	3,483	97%	44,519	Lamps
Aerators	3,265	91%	3,265	Aerators
Smart-Strips	3,173	89%	3,173	Strips
HVAC Filters	2,798	78%	33,476	Filters
Water Heater Pipe Wraps (1 ft)	907	25%	2,708	Feet
Water Heater Blanket	630	18%	630	Blankets
Water Heater Temperature Adjustment	78	2%	78	Adjustments
Mobile Home Measures (N=100 customers)				
Digital Switch Plate Wall Thermometer	100	100%	100	Thermometers
Duct Sealing with > 10% Reduction	97	97%	97	Participants
Air Sealing > 30% Leakage Reduction	50	50%	50	Participants
Air Sealing > 40% Leakage Reduction	50	50%	50	Participants
Attic Plug & Fill Insulation (R-30)	39	39%	43,185	Square Feet
Programmable Communicating Thermostat	9	9%	9	Thermostats
Reflective Roof Coating	8	8%	9,045	Square Feet
Belly Board Repair	4	4%	354	Square Feet
WiFi Enable Thermostat	2	2%	2	Thermostats
CO Monitor	5	5%	5	Monitors
Total	3,586	N/A	140,746	

a. Does not account for persistence rates.

3.5.3 Impact and Data-Tracking Findings

The Evaluation Team performed a thorough review of the Core and Mobile Home program-tracking databases and found no duplicative records. However, the team found that DESC excluded nine participants who only received mobile home pilot measures from the ex-ante participation counts, as the ex-ante assumption was that all Mobile Home participants received Core measures. Adding these 9 participants brought the total

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number of participants from 3,577 to 3,586. Core and Mobile Home savings were accurately tracked in their separate program-tracking databases, as such, savings and measure counts were not affected by this error.

As shown in Table 45, ex-post results for PY8 apply persistence rates to Core measures, based on PY5 evaluation results. However, for Core measures newly introduced in PY7 (i.e., LEDs and Kitchen Faucet Aerators), the Evaluation Team applied a 100% persistence rate as these measures have not yet been evaluated. The team plans to develop persistence rates for these measures in future program years using updated survey results.

Table 45. NEEP Verified Measure Volume

Measure Type	Ex-Ante Measure Quantity	Verification Rate	Ex-Post Measure Quantity
Core Program Measures			
LEDs	44,519	100%	44,519
Aerators	3,265	100%	3,265
Smart-Strips	3,173	93%	2,951
HVAC Filters	2,798	100%	2,798
Water Heater Pipe Wraps (1 ft)	2,708	94%	2,546
Water Heater Blanket	630	92%	580
Water Heater Temperature Adjustment	78	100%	78
Mobile Home Measures	52,897	100%	52,897
Total	110,068	100%	109,633

Core Measures Ex-Post Gross Savings Adjustments

The Evaluation Team reviewed the Core program-tracking database to ensure the appropriate application of deemed savings values. Aside from minor rounding issues, the only other source of discrepancy between ex-ante and ex-post was for HVAC Filters KW savings. Table 46 compares the per-unit ex-ante and ex-post deemed savings estimates for each measure, with green highlights showing the two areas of discrepancy.

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Table 46. NEEP Ex-Ante and Ex-Post Deemed Savings Values For Core Measures (Per-Unit)

Measure Description	Unit	Ex-Ante		Ex-Post		% Difference		Reason for Difference
		KWH	KW	KWH	KW	KWH	KW	
LED 40W Equivalent	Per lamp	37.23	0.003	37.23	0.003	100%	100%	N/A
LED 60W Equivalent	Per lamp	54.75	0.005	54.75	0.005	100%	100%	
LED 75W Equivalent	Per lamp	68.99	0.006	68.99	0.006	100%	100%	
LED100W Equivalent	Per lamp	94.17	0.009	94.17	0.009	100%	100%	
HVAC Filters (Heating & Cooling)	Per participant	64	0.015	64.00	0.015	100%	100%	N/A
HVAC Filters (Cooling Only)	Per participant	32.00	0.015	32.00	0.018	100%	120%	Ex-ante applied incorrect KW deemed savings values
HVAC Filters (Heating Only)	Per participant	32.00	0	32.00	0	100%	N/A	N/A
Kitchen Faucet Aerator	Per Aerator	225	0.011	225.00	0.011	100%	100%	N/A
Pipe Wrap 1 foot	Per foot	13.72	0.002	13.72	0.002	100%	78%	Rounding
Smart-Strip	Per strip	102.8	0.012	102.80	0.012	100%	100%	N/A
Water Heater Blanket	Per blanket	360.8	0.041	360.80	0.041	100%	100%	N/A
Water Heater Temperature Adjustment	Per WH	113.84	0.013	113.84	0.013	100%	100%	N/A

Note: Some values in this table do not sum or divide exactly due to rounding.

Mobile Home Ex-Post Gross Savings Adjustments

The Evaluation Team calculated ex-post gross savings by applying measure-specific deemed savings to each measure within the PY8 Mobile Home program-tracking database, then determined average per-participant savings by dividing the ex-post gross savings by the total number of participants (n=100). As shown in Table 47, ex-post KWH savings per mobile home exceeded ex-ante savings estimates by approximately 10%.

Table 47. NEEP Ex-Ante and Ex-Post Average per Mobile Home Savings

Ex-Ante Gross Savings		Ex-Post Gross Savings	
KWH	KW	KWH	KW
1,705	0.470	1,880	0.492

DESC estimated ex-ante savings using the PY7-evaluated savings per mobile home. Key differences between ex-ante (PY7) and ex-post (PY8) per mobile home savings are:

- **Increased Measure Quantity and Program Participation:** On average, the total number of installed measure quantities in PY8 increased by 39% and participation increased by 25% compared to PY7. Because measure quantities increased more than participation, the Evaluation Team expected a higher per-mobile home savings value in PY8 compared to PY7.
- **Assumed Heating Fuel and Equipment Types:** Similar to PY7, the Evaluation Team relied on the program-tracking database to determine the share of participants with cooling versus electric heating. In PY8, the number of participants with central cooling was comparable to PY7 (97% in PY8 compared to 96% in PY7) but the number of participants with electric heating increased from 83% in PY7 to 91% in PY8. As a result of the higher percentage of participants with electric heating, the ex-post per-mobile home savings increased.

Refer to Appendix E for a more detailed description of ex-post savings methods and differences between ex-ante and ex-post gross savings for the Mobile Home component.

Mobile Home Savings as a Percentage of Baseline Usage

To put savings into context, the Evaluation Team compared average savings per participant from the Mobile Home component to the baseline usage for single-family and mobile homes, respectively. As shown in Table 48, mobile home customers' average energy usage is approximately 4% higher than single-family customers' average energy usage. Considering this information, the KWH savings from the Mobile Home component would reduce the average mobile home customer's annual energy usage by 13%, bringing their annual use to below the single-family customer average.

Table 48. NEEP Mobile Home Savings Comparison to Baseline Usage

Baseline Annual Usage (KWH)		Mobile Home Savings Per Participant (KWH)	Estimated Average Mobile Home Usage After Participation
Single-Family	Mobile Home		
13,654	14,135	1,880	12,255

Source: Data on baseline annual usage provided by DESC.

Total Program Ex-Post Gross Impacts

Table 49 presents the per-measure ex-ante and ex-post gross savings by program component. The overall RRs for the program are 0.99 for both MWH and MW savings.

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Table 49. NEEP Ex-Post Gross Savings Summary

Measure	Ex-Ante Gross Savings		Ex-Post Gross Savings		Gross RR	
	MWH	MW	MWH	MW	MWH	MW
Core Measures						
LEDs	2,440	0.223	2,440	0.223	1.00	1.00
Aerators	735	0.036	735	0.036	1.00	1.00
Smart-Strips	326	0.038	303	0.035	0.93	0.93
Water Heater Blanket	227	0.026	209	0.024	0.92	0.92
HVAC Filters	171	0.042	171	0.042	1.00	1.02
Water Heater Pipe Wraps (1 ft)	37	0.005	35	0.004	0.94	0.74
Water Heater Temperature Adjustment	9	0.001	9	0.001	1.00	1.00
<i>Core Measures Subtotal</i>	3,946	0.370	3,902	0.365	0.99	0.99
Mobile Home Measures	170	0.047	188	0.049	1.10	1.05
Total	4,116	0.417	4,090	0.414	0.99	0.99

Note: Some values in this table do not sum or divide exactly due to rounding.

Net Impacts

The Evaluation Team applied a NTGR of 1.0, which is a common assumption when evaluating low-income programs as most customers are highly unlikely to install these measures or take additional action without the program due to income constraints. As a result, the ex-post net savings are identical to the ex-post gross savings of 4,090 MWH and 0.41 MW, as shown in Table 50.

Table 50. NEEP Ex-Post Net Savings Summary

Ex-Post Gross Savings		NTGR		Ex-Post Net Savings	
MWH	MW	MWH	MW	MWH	MW
4,090	0.41	1.00	1.00	4,090	0.41

3.6 Appliance Recycling Program

3.6.1 Program Description

The Appliance Recycling Program (ARP) offers incentives to DESC residential customers who recycle less-efficient, but operable, primary and secondary refrigerators and/or stand-alone freezers. In addition to the incentive, recycled appliances are picked up free of charge. The program generates energy savings by removing the less-efficient measures from the market so that they do not continue to operate inefficiently within DESC's service territory. The program is implemented with assistance from ARCA, Inc. and offered to active residential electric customers seeking to recycle operational appliances between 10 and 30 cubic feet. Customers receive a \$50 rebate per appliance and are limited to two rebates per program year.

3.6.2 Program Performance Summary

The program reported a total of 3,444 recycled appliances for 3,267 participants. The program exceeded its forecasted energy and demand savings through higher-than-expected participation and higher ex-post per

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measure savings compared to ex-ante for both refrigerators and freezers. The program's actual versus forecasted results are shown in Table 51.

Table 51. ARP Forecasts and Results

Metric	Forecast	Actual	% of Forecast
Cost	\$616,126	\$689,664	112%
Participants (customers)	3,087	3,267	106%
Gross MWH Savings	2,355	3,473	147%
Gross MW Savings	0.29	0.40	137%
Net MWH Savings	N/A	2,171	N/A
Net MW Savings	N/A	0.26	N/A

Note: Some values in this table do not sum or divide exactly due to rounding.

Table 52 summarizes the number of unique participants and the number of recycled appliances in PY8. The majority (95%) of participants recycled one appliance.

Table 52. ARP Total Recycled Appliances and Unique Participants

Number and Type of Appliance	Total PY8 Measures	Number of Unique Participants	% of Measure Total	% of Participant Total
1 Refrigerator	2,568	2,568	75%	79%
1 Freezer	522	522	15%	16%
1 Refrigerator & 1 freezer	176	88	5%	3%
2 Refrigerators	154	77	5%	2%
2 Freezers	24	12	1%	0.4%
Total	3,444	3,267	100%	100%

3.6.3 Impact and Data-Tracking Findings

The Evaluation Team performed a thorough review of the program-tracking database and found no duplicative records or tracking errors, thus, no adjustments to ex-ante measure quantities were needed. The Evaluation Team applied a 100% verification rate established through the PY5 evaluation to arrive at the total ex-post measure quantity. Table 53 compares the ex-ante and ex-post measure quantities evaluated in PY8.

Table 53. ARP Number of Measures Rebated

Measure Type	Ex-Ante Measure Quantity	Verification Rate	Ex-Post Measure Quantity
Refrigerator	2,810	100%	2,810
Freezer	634	100%	634
Total	3,444	100%	3,444

To calculate ex-ante savings, DESC applied the PY7 ex-post deemed savings values for refrigerators and freezers. The Evaluation Team calculated ex-post savings in PY8 by applying the UMP protocols², which is

² Source: The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 7: Refrigerator Recycling Evaluation Protocol. <https://www.nrel.gov/docs/fy17osti/68563.pdf>

Program-Specific Findings

consistent with the methodology used to calculate ex-post savings in PY7. Appendix F provides detailed methods and results from the engineering analysis.

As shown in Table 54, the program achieved 3,473 MWH and 0.40 MW in ex-post gross savings. Ex-post gross impacts are greater than ex-ante, with overall gross RR of 1.05 for both energy and demand savings. Differences in ex-ante and ex-post gross savings are driven by the variation in appliance characteristics including appliance age, size (i.e., cubic feet), type (i.e., single door, side-by-side, chest), and whether it was a primary or secondary appliance.

Table 54. ARP Ex-Post Gross Savings Summary

Measure Type	Ex-Post Quantity	Ex-Ante Gross Savings		Ex-Post Gross Savings		Gross RR	
		MWH	MW	MWH	MW	MWH	MW
Refrigerator	2,810	2,888	0.33	3,004	0.34	1.04	1.04
Freezer	634	431	0.05	468	0.05	1.09	1.08
Total	3,444	3,319	0.38	3,473	0.40	1.05	1.05

Note: Some values in this table do not sum or divide exactly due to rounding.

The Evaluation Team applied self-reported NTGRs based on PY5 evaluation results to the PY8 ex-post gross savings values to determine ex-post net savings. As shown in Table 55, the program achieved ex-post net savings of 2,171 MWH and 0.26 MW.

Table 55. ARP Ex-Post Net Savings Summary

Measure Type	Ex-Post Gross Savings		NTGR		Ex-Post Net Savings	
	MWH	MW	MWH	MW	MWH	MW
Refrigerator	3,004	0.34	0.61	0.64	1,837	0.22
Freezer	468	0.05	0.71	0.74	334	0.04
Total	3,473	0.40	0.63	0.65	2,171	0.26

Note: Some values in this table do not sum or divide exactly due to rounding.

3.7 EnergyWise for Your Business Program

3.7.1 Program Description

The EnergyWise for Your Business (EWfYB) Program offers incentives to businesses to encourage installation of high-efficiency equipment and building improvements that reduce energy costs. ICF assists DESC with the implementation of EWfYB. The program is available to eligible C&I customers in the DESC electric service area. At the close of PY8, 434 large commercial and industrial accounts, representing approximately 25% of DESC's retail electric load, had opted out of DESC's DSM programs. The program includes both prescriptive and custom incentives. The Evaluation Team combined these two components in this report for simplicity and because they are implemented as one program.

3.7.2 Program Performance

Table 56 shows the program's PY8 performance in comparison to the forecast. Higher participation as well as higher MWH and MW savings per-project led to the program exceeding its energy and demand savings goals.

Program-Specific Findings

Table 56. EWfYB Forecasts and Results

Metric	Forecast	Actual	% of Forecast
Program Cost	\$4,629,850	\$5,392,285	117%
Participation (Projects)	670	767	114%
Gross MWH Savings	32,582	47,950	147%
Gross MW Savings	6.02	8.25	137%
Net MWH Savings	N/A	33,524	N/A
Net MW Savings	N/A	6.10	N/A

As with previous years, prescriptive lighting measures continue to drive program savings, accounting for 83% and 86% of ex-post energy and demand savings, respectively. Prescriptive lighting project number SCPLPS1534796113 was broken out from the rest of the prescriptive lighting projects when evaluating all impacts. This project number is associated with a customer who, after applying for and receiving pre-approval for an incentive, declined the incentive check and instead opted out of the rate rider for energy efficiency programs. Based on discussions with the implementer, the customer, and program staff, the Evaluation Team included this customer in the PY8 participant population but call them out separately since this customer did not receive an incentive for the project.

Table 57. EWfYB Savings by Project Type

Project Type	Number of Projects	Percent of Ex-Post MWH	Percent of Ex-Post MW
Prescriptive Lighting			
Prescriptive Lighting	660	76%	81%
Prescriptive New Construction Lighting	20	4%	3%
Project # SCPLPS1534796113	1	3%	1%
Prescriptive Non-Lighting and Custom			
Custom Incentives	21	12%	9%
Prescriptive Chillers	8	2%	2%
Prescriptive Unitary HVAC	32	2%	3%
Other Prescriptive Non-Lighting	25	1%	0%
Total	767	100%	100%

3.7.3 Impact and Data Tracking Findings

The Evaluation Team calculated ex-ante energy savings by reviewing the reported savings against the program-tracking database and summing the tracked savings for each completed project. The impact evaluation included multiple steps to calculate ex-post savings. The first step checked the accuracy of the program database. Next, the Evaluation Team performed desk reviews on a sample of projects to assess accuracy and reasonableness of ex-ante savings estimates and determine ex-post gross savings. Third, the ex-post net analysis accounts for program FR and spillover by applying a NTGR to ex-post gross savings. Detailed results of the analysis at the individual project level are contained in Appendix G.

Program-Specific Findings

Database Review

The Evaluation Team reviewed the program-tracking database to verify the application of ex-ante savings. The Evaluation Team found no discrepancies and, therefore, did not adjust ex-ante savings. As seen from Table 58, the program-tracking database accurately reflected the application of savings.

Table 58. EWfYB Database Review Adjustments

Application Type	Ex-Ante Gross		Verification Rate		Revised Gross	
	MWH	MW	MWH	MW	MWH	MW
Prescriptive Lighting	35,593	7.22	100%	100%	35,593	7.22
Custom Incentives	5,591	0.70	100%	100%	5,591	0.70
Prescriptive New Construction Lighting	2,018	0.37	100%	100%	2,018	0.37
Prescriptive Chillers	632	0.13	100%	100%	632	0.13
Prescriptive Unitary HVAC	1,140	0.22	100%	100%	1,140	0.22
Other Prescriptive Non-Lighting	516	0.04	100%	100%	516	0.04
Project # SCPLPS1534796113	1,351	0.12	100%	100%	1,351	0.12
Total	46,841	8.81	100%	100%	46,841	8.81

Project Desk Reviews

The Evaluation Team evaluated savings for PY8 by conducting engineering desk reviews on sampled projects across each of the different application types within the EWfYB program. Using interim data received in September 2018, the team developed a stratified random sample approach for prescriptive lighting, custom projects, and other prescriptive non-lighting projects and a simple random sample for the new construction lighting and unitary HVAC projects. Due to the relatively small number of chiller projects, the team decided to review the full population rather than a sample. Table 59 provides a comparison of ex-ante gross and ex-post gross savings. RRs were primarily driven by differences between ex-ante savings application methods and the recommended methods in DESC's CEAM³. Notably, while some RRs are significantly above or below 100%, the overall RRs for the program are 102% for MWH and 94% for MWs, reflecting that the ex-ante savings estimates were largely accurate amongst sampled projects with the largest savings.

³ The Evaluation Team developed the DESC CEAM to document all evaluated savings calculations and assumptions. After a review and comparison of several TRMs, the Evaluation Team chose to reference the Texas TRM for lighting coincidence factors in the CEAM. Texas TRM reference: Public Utility Commission of Texas. Texas Technical Reference Manual Version 2.0, Volume 3: Nonresidential Measures. April 18, 2014.

Program-Specific Findings

Table 59. EWfYB Ex-Post Gross Savings Summary

Application Type	Ex-Ante		Ex-Post		Gross RR	
	MWH	MW	MWH	MW	MWH	MW
Prescriptive Lighting	35,593	7.22	36,580	6.69	103%	93%
Custom Incentives	5,591	0.70	5,522	0.72	99%	103%
Prescriptive New Construction Lighting	2,018	0.37	2,052	0.27	102%	74%
Prescriptive Chillers	632	0.13	1,157	0.13	183%	101%
Prescriptive Unitary HVAC	1,140	0.22	764	0.28	67%	125%
Other Prescriptive Non-Lighting	516	0.04	487	0.04	94%	100%
SCPLPS1534796113	1,351	0.12	1,388	0.12	103%	93%
Total	46,841	8.81	47,950	8.25	102%	94%

Note: Some values in this table do not sum or divide exactly due to rounding.

Summary of Ex-Ante and Ex-Post Discrepancies

Table 60 below summarizes the key drivers of RRs by project type. More detail by application type is provided in Appendix G.

Table 60. EWfYB Summary of Differences Between Ex-Ante and Ex-Post Estimates

Application Type	Gross RR		Reason for Difference
	MWH	MW	
Prescriptive Lighting	103%	93%	<ul style="list-style-type: none"> Ex-ante estimates used generalized (average) coincidence factors in some cases; ex-post estimates used CEAM-recommended, building-type specific coincidence factors Some exterior lighting measures were specified as interior lighting projects.
Prescriptive New Construction Lighting	102%	74%	
SCPLPS1534796113	103%	93%	
Custom Incentives	99%	103%	<ul style="list-style-type: none"> HVAC (5 projects): Inconsistency between ex-ante reported demand savings and the demand savings from the model output in one project. Lighting Controls (1 project): The Evaluation Team calculated savings in accordance with the CEAM, including demand savings using an appropriate coincidence factor for the space type, whereas ex-ante did not report demand savings. Air Compressor System (1 project): Insufficient meter data available to verify modeling outputs; the Evaluation Team determined that ex-ante claimed savings from the metering data were nearly double that of the algorithmically calculated savings. Refrigeration (1 project): Adjustments to fan affinity calculations
Prescriptive Chillers	183%	101%	Baseline efficiencies did not align with the CEAM-specified minimum baseline efficiencies.
Prescriptive Unitary HVAC	67%	125%	Ex-post updated baseline minimum efficiency values to align with 2018 federal standards.
Other Prescriptive Non-Lighting	94%	100%	Ex-post made adjustments to hours of operation assumptions for LED refrigerated case lighting and control measures.

Net Verified Savings

Table 61 shows the ex-post net energy and demand savings that the program achieved in PY8. The NTGR used for all but one project is the value used in PY8 program planning and has been used in the evaluation since PY3. For project number SCPLPS1534796113, the team called the customer to more accurately understand the influence that the program played in moving forward with the project. The customer indicated that the program incentive was not a factor in their decision to do the project and they would have moved forward without a utility-sponsored incentive. Therefore, the team applied a NTGR of 0 for this project.

Table 61. EWfYB Ex-Post Net Savings Summary

Application Type	Ex-Post Gross Savings		NTGR		Ex-Post Net Savings	
	MWH	MW	MWH	MW	MWH	MW
All Other Applications	46,561	8.13	0.72	0.75	33,524	6.10
Project # SCPLPS1534796113	1,388	0.12	0.00	0.00	0.00	0.00
Total	47,950	8.25	0.70	0.74	33,524	6.10

Note: Some values in this table do not sum or divide exactly due to rounding.

3.8 Small Business Energy Solutions

3.8.1 Program Description

The Small Business Energy Solutions (SBES) Program originated to serve a market that was underserved in the EnergyWise for Your Business (EWfYB) Program. SBES participation is restricted to small businesses or nonprofits who have five or fewer DESC electric accounts and annual energy usage of no more than 350,000 KWH.

The program offers a no-cost on-site energy audit and equipment incentives for lighting and refrigeration. While the SBES Program offers fewer measures than EWfYB, the financial incentives offered are higher to help overcome cost barriers often faced by small businesses. SBES covers up to 80% of the pre-tax project costs of energy efficient technologies pursued through the program, not to exceed \$6,000 per utility account per program year.

ICF administers the program and sub-contracts to Facility Solutions Group (FSG) for lighting measures and National Resource Management (NRM) for refrigeration measures. FSG and NRM use local contractors to perform installations.

3.8.2 Program Performance Summary

The PY8 program achieved strong RRs and a high NTGR but, as Table 62 shows, the program fell short of participation goal, and thus did not meet its savings goals. According to program staff, the key driver of lower participation was decreased interest in the program during the first half of the year because T-LEDs were unavailable. Once TLEDs became available in mid-June 2018, participation increased.

Program-Specific Findings

Table 62. SBES Forecasts and Results

Metric	Forecast	Actual	% of Forecast Accomplished
Cost	\$2,652,473	\$1,965,219	74%
Participation (Projects)	654	461	70%
Gross MWH Savings	5,389	5,124	95%
Gross MW Savings	1.83	1.48	81%
Net MWH Savings	N/A	4,865	N/A
Net MW Savings	N/A	1.45	N/A

Participant Overview

The majority (82%) of program energy savings come from lighting projects, while refrigeration measures account for the remaining 18% of energy savings. More than eleven types of business segments participated in the program. The highest contributing segments to lighting savings were retail, industrial processing, and offices (64% of ex-ante lighting KWH savings). The highest contributing segment to savings for refrigeration measures was grocery establishments (96% of ex-ante refrigeration KWH savings). Table 62 lists each segment with associated participation levels and savings.

Table 63. SBES Participation and Savings by Segment

Segment	Projects	Ex-Ante Savings		% Ex-Ante Savings	
		MWH	MW	MWH	MW
Lighting	402	4,212	0.97	82%	94%
Retail	100	1,058	0.28	21%	27%
Industrial Processing	66	863	0.20	17%	19%
Office	79	792	0.22	15%	21%
Religious Facility	41	375	0.10	7%	9%
Grocery	19	236	0.02	5%	2%
Other	36	271	0.04	5%	4%
Health Facility	17	193	0.05	4%	5%
Restaurant	15	119	0.02	2%	2%
Warehouse	11	106	0.03	2%	3%
Multifamily	7	94	0.01	2%	0%
School	3	53	0.01	1%	1%
Lodging	8	52	0.00	1%	0%
Refrigeration	64	906	0.07	18%	6%
Grocery	60	868	0.06	17%	6%
Retail	3	36	0.00	1%	0%
Restaurant	1	2	0.00	0%	0%
Grand Total	461^a	5,118^b	1.03	100%	100%

Note: Some values in this table do not sum or divide exactly due to rounding.

a. Numbers do not total to 461 projects because some projects included both lighting and refrigeration measures

b. Due to a rounding error, the ex-ante MWH savings reported in the January 2019 filing was 5,117.

3.8.3 Impact and Data-Tracking Findings

The impact evaluation included several steps to calculate ex-post savings. The first step included a high-level database validation. The second step included performing detailed desk reviews on a sample of projects within the lighting and refrigeration end-uses to determine ex-post gross savings. The final step was to apply NTGRs to estimate ex-post net savings.

Database Validation

The Evaluation Team performed a thorough review of the program-tracking database and found no duplicative records or tracking errors, thus, no adjustments to ex-ante measure quantities were needed (Table 64).

Table 64. SBES Database Review Adjustments

Measure Category	Ex-Ante Gross		Revised Gross		Tracking Accuracy	
	MWH	MW	MWH	MW	MWH	MW
Lighting	4,212	0.97	4,212	0.97	100%	100%
Refrigeration	906	0.07	906	0.07	100%	100%
Total	5,118	1.03	5,118	1.03	100%	100%

Note: Some values in this table do not sum or divide exactly due to rounding.

Project Desk Reviews

The Evaluation Team evaluated savings for PY8 by conducting engineering desk reviews on a stratified random sample of projects from the lighting and refrigeration measures. The team developed RRs at the sampled project level and then weighted the sampled projects by savings to establish population-level RRs. While KWH RRs approximately equal 100%, KW RRs greater than 100% on average. Table 65 provides a comparison of ex-ante gross and ex-post gross savings.

Table 65. SBES Ex-Post Gross Savings Summary

Measure Category	Ex-Ante Gross		Ex-Post Gross		RR	
	MWH	MW	MWH	MW	MWH	MW
Lighting	4,212	0.97	4,219	1.41	1.00	1.45
Refrigeration	906	0.07	905	0.08	1.00	1.16
Total	5,118	1.03	5,124	1.48	1.00	1.44

Note: Some values in this table do not sum or divide exactly due to rounding.

For lighting measures, the Evaluation Team developed all ex-post calculations in accordance with the recommended methods in CEAM⁴. Based on this evaluation, the Evaluation Team identified some minor updates to the CEAM to more closely align ex-ante and ex-post methodologies and will publish a new CEAM for PY9. Lighting KW RRs greater than 100% were driven largely by the omission of ex-ante savings for exterior lighting measures. The Evaluation Team also applied the CEAM-aligned coincidence and waste heat factors to ex-post calculations, which the ex-ante estimates did not. For the refrigeration program component, high KW

⁴ The Evaluation Team developed the CEAM to document all evaluated savings calculations and assumptions. After a review and comparison of several TRMs, the Evaluation Team chose to reference the Texas TRM for lighting coincidence factors in the CEAM. Texas TRM reference: Public Utility Commission of Texas. Texas Technical Reference Manual Version 2.0, Volume 3: Nonresidential Measures. April 18, 2014.

Program-Specific Findings

RRs were primarily driven by demand savings not being included in the database for novelty cooler night setback measures. More detail by end-use is provided in Appendix H.

Net Savings

As shown in Table 66, SBES achieved 4,865 MWH and 1.45 MW in ex-post net savings. To arrive at ex-post net savings, the Evaluation Team applied PY5-evaluated NTGRs for lighting and PY8-evaluated NTGRs for refrigeration to ex-post gross savings. The PY8 NTGR for refrigeration was determined by an online participant survey administered to a sample of program participants to determine free ridership and spillover. As is consistent with small business programs, participant free ridership scores were very low, indicating that the program highly influenced participants to install energy efficiency measures. More detail on the PY8 refrigeration NTGR is available in Appendix H.

Table 66. SBES Ex-Post Net Savings Summary

Measure Category	Ex-Post Gross Savings		NTGR		Ex-Post Net Savings	
	MWH	MW	MWH	MW	MWH	MW
Lighting	4,219	1.41	0.96	0.98	4,050	1.38
Refrigeration	905	0.08	0.90	0.89	814	0.07
Total	5,124	1.48	0.95	0.98	4,865	1.45

Appendix A. PY8 Survey Response Rates and Representativeness

The table below describes the survey methodology and representativeness across all surveys fielded for PY8 evaluation. These surveys provided the data needed to calculate NTGR and/or ISRs for several programs.

Table 67. PY8 Survey Methods and Response Results

Program Component	Target	Population Size	Number of Responses	Sampling Method	% of Population Represented in Survey Results	Sample Precision at 90/10
Heating & Cooling	Participating Customers	4,050 customers, 4,452 measures	339 customers, 378 measures	Census	8% customers 8% of measures	n/a given census attempt
	Participating Contractors	397 contractors, 4,452 measures	23 contractors, 859 measures	Convenience Sample based on email availability	6% of contractors 19% of measures	0.02%
Small Business Energy Solutions	Refrigeration participating customers	62 customers, 696 measures	15 customers, 166 measures	Census	24% of customers 24% of measures	n/a given census attempt
Home Energy Check-up	Participating customers	3,460 customers	497 customers	Census	14% of participating customers	n/a given census attempt

Appendix B. ENERGY STAR® Lighting Detailed Methods

Gross Impacts Detailed Methods

This section details the methodology and assumptions used to estimate revised, gross, and net energy and demand savings for products distributed through the PY8 Residential Lighting Program.

Product offerings differed between the three distinct program components. DESC customers purchasing products through the Online Store could choose between a variety of standard, reflector and specialty lighting products available in various wattages and pack sizes, and several advanced power strip products. BOL participants received a free kit with five standard LED bulbs: three 10W; one 12W; one 14W. Low-Income Free LED Kits participants each received five standard 10W LED bulbs.

Despite the differences in offerings, the Evaluation Team used a similar approach to calculating energy and demand savings across the three components.

LED Lighting Engineering Algorithms and Assumptions

Equation 1 and Equation 2 provide the formulas used to calculate revised energy and demand savings for lighting products.

Equation 1. Lighting Revised Gross Energy Savings Formula

$$KWh\ Savings = (HOU \times 365) \times (W_{Base} - W_{Eff}) \times WHFe / 1000$$

Equation 2. Lighting Revised Gross Demand Savings Formula

$$KW\ Savings = (W_{Baseline} - W_{Eff}) \times WHFd \times CF / 1000$$

Where:

<i>KWh Savings</i>	= first-year energy savings
<i>KW Savings</i>	= first-year peak demand savings
<i>HOU</i>	= Average hours of use per day
<i>W_{Base}</i>	= Baseline wattage
<i>W_{Eff}</i>	= Wattage of the energy efficient replacement
<i>WHFe</i>	= Waste heat factor for energy use, accounts for the effects of more efficient lighting on cooling energy use
<i>WHFd</i>	= Waste heat factor for demand, accounts for the effects of more efficient lighting on cooling energy demand
<i>CF</i>	= Coincidence factor

Equation 3 and Equation 4 provide the formulas used to calculate ex-post gross and ex-post net savings for lighting products.

Appendices

Equation 3. Lighting Ex-Post Gross Savings Formula

$$\text{Ex-Post Gross} = \text{Revised Gross} * \text{First-Year ISR}$$

Equation 4. Lighting Ex-Post Net Savings Formula

$$\text{Ex-Post Net} = \text{Ex-Post Gross} * \text{NTGR}$$

The following subsections detail the sources of each savings assumption used to calculate ex-post savings from lighting products.

Hours of Use

The Evaluation Team used a daily hours of use (HOU) estimate of 3.0 hours per day to calculate energy savings for program measures. An DESC-specific HOU estimate is unavailable and is likely to be very similar to other jurisdictions. As such, the Evaluation Team completed a secondary review of past research studies across a range of jurisdictions and developed a reasonable HOU estimate based on the average of these studies. The results of the secondary research and the recommended HOU estimate are provided in Table 68.

Table 68. Lighting Program Comparative Summary of Lighting HOU

Source	Daily Hours of Use
Ohio TRM (Sept 2009)	3.63
New York State EEPS (Oct 2010)	3.20
ENERGYSTAR.gov Calculator (Apr 2009)	3.00
Mid-Atlantic TRM v. 2.0 (July 2011)	2.98
Ohio TRM (August 2010)	2.85
Massachusetts TRM (Oct 2010)	2.80
ComEd (2011)	2.74
Maine (Feb 2007)	2.70
Connecticut (Sept 2007)	2.60
South Carolina (2012)	2.44
Recommended	3.00

Baseline Wattage

Traditionally, the baseline wattage for energy efficient products has been an incandescent light bulb. However, the provisions of the 2007 EISA rulings have gradually increased the efficiency requirements of general service incandescent light bulbs. The regulations were phased in over several years, affecting 100-watt general service incandescents in January 2012, 75-watt incandescents in January 2013, and 60-watt and 40-watt incandescents in January 2014. Manufacturers responded to EISA by developing halogen bulbs that meet the new efficiency standards. These new “EISA-compliant” halogens ultimately took the place of incandescents as the efficient baseline for calculating program savings. Affected incandescents are now assumed to be virtually non-existent on store shelves.

As part of the engineering desk review, the Evaluation Team cross-referenced product descriptions with assigned wattages, baseline wattages, and lumen ranges. Final baseline wattages were assigned for each product based on verified lumen counts.

Appendices

Table 69 provides the post-EISA 2007 baseline wattage by lumen range for standard products.

Table 69. Lighting Program Baseline Wattages for Standard Bulbs

Lumen Range	Incandescent-Equivalent Wattage	Post-EISA Baseline Wattage
250–309	<40	25
310–749	40	29
750–1,049	60	43
1,050–1,489	75	53
1,490–2,600	100	72
2,601–2,999	150	150
3,000–5,279	200	200
5,280–6,209	300	300

In addition to general service products, certain directional products are subject to Department of Energy (DOE) energy efficiency standards that went into effect at the beginning of 2012.⁵ The legislation affected directional LEDs depending on the bulb type and lumen range. As a result, the Evaluation Team applied the following baseline wattages for directional LED products.

Table 70. Lighting Program Baseline Wattages for Directional Bulbs

Reflector Bulb Type	Lumen Range	Reflector Bulb Baseline Wattage
R, PAR, ER, BR, BPAR, or similar bulb shapes with medium screw bases and diameter >2.5"	600-849	50
	850-999	55
	1,000-1,300	65
ER30, BR30, BR40, ER40	400-449	40
	450-499	45
	500-1,419	65
R40	400-449	40
	450-719	45
All reflector lamps below the lumen ranges specified above	200-299	30
	300-399	40

Products exempt from both EISA and DOE legislation were assigned an incandescent baseline wattage based on verified lumen counts.

⁵ Department of Energy. 10 CFR 430 Energy Conservation Program: Energy Conservation Standards and Test Procedures for General Service Fluorescent Lamps and Incandescent Reflector Lamps: Final Rule. July 2009.

Appendices

Efficient Product Wattage

The Evaluation Team used actual wattages of the efficient products as specified on the product packaging by product manufacturers. The Evaluation Team consulted program staff or performed internet lookups for a small number of products with inconsistent wattages recorded in program-tracking data.

Waste Heat Factors

The inclusion of waste heat factors for lighting is based on the concept that heating loads increase to supplement the reduction in heat that was once provided by incandescent lamps and cooling loads decrease since there is less heat output from the incandescent lamp that was once in place. The overall effects are complicated to determine, as they are influenced not just by the type of lighting used, but also by the climate and the type of HVAC systems used to heat and cool the home. Waste heat factors developed for one climate region cannot be used in another, since the climate and the mix of heating and cooling use vary across the country. DESC currently does not have waste heat factor estimates that are specific to its territory and fuel mix. The Evaluation Team therefore used an energy and demand waste heat factor of 1.0.

Coincidence Factor

The Evaluation Team used a coincidence factor (CF) of 0.10 to calculate demand savings during the peak summer period. A DESC-specific CF estimate is unavailable. As such, the Evaluation Team completed a secondary review of past research studies across a range of jurisdictions and developed a reasonable CF estimate, which represents the average across all studies. The results of the secondary research and the recommended CF estimate are provided in Table 71.

Table 71. Lighting Program Comparative Summary of Coincidence Factors

Source	Coincidence Factor
Ohio TRM (Sept 2009)	0.15
Massachusetts TRM (Oct 2010)	0.11
Mid-Atlantic TRM v. 2.0 (July 2011)	0.11
Ohio TRM (August 2010)	0.11
South Carolina (2012)	0.10
Maine (Feb 2007)	0.10
Connecticut (Sept 2007)	0.08
New York State EEPS (Oct 2010)	0.08
Recommended	0.10

Appendices

Advanced Power Strip Engineering Algorithms and Assumptions

For advanced power strips sold through the Online Store in PY8, the Evaluation Team applied deemed savings values based on research conducted across a range of geographic areas and program delivery models. These deemed savings values are recommended by the Illinois TRM Version 7.0, which provides separate values for 5-outlet and 7-outlet measures. The Evaluation Team therefore used the 5-outlet recommended values to estimate savings for 4-outlet advanced power strips and the 7-outlet recommended values to estimate savings for 7- and 12-outlet advanced power strips. The applied per-unit savings values are summarized in Table 72.

Table 72. Lighting Program Advanced Power Strip Revised Gross Savings

Product	Per-Unit KWH	Per-Unit KW
Advanced Power Strip - Tier 1 (4-outlet)	56.5	0.006
Advanced Power Strip - Tier 1 (7-outlet)	103	0.012
Advanced Power Strip - Tier 1 (12-outlet)	103	0.012

Measure-Level Savings Summary

Table 73 contains tracked and verified measures and savings by product.

Appendices

Table 73. Lighting Program Summary of Gross Savings by Program and Measure Type

Program Component	Measure Type	Wattage	Verified Units Sold	Ex-Ante Tracked Savings		Gross Revised Savings		Gross Savings RR (Before ISR)	
				KWH	KW	KWH	KW	KWH	KW
Online Store	Standard LED	6	909	22,898	1.82	22,893	2.09	100%	115%
Online Store	Standard LED	7.5	316	12,283	1.26	12,284	1.12	100%	89%
Online Store	Standard LED	9	121,062	4,507,138	363.19	4,507,138	411.61	100%	113%
Online Store	Standard LED	9.5	309	11,334	0.93	11,335	1.04	100%	112%
Online Store	Standard LED	10	11	398	0.03	397	0.04	100%	110%
Online Store	Standard LED	14	237	10,122	0.95	10,121	0.92	100%	97%
Online Store	Standard LED	18	683	40,386	3.41	40,386	3.69	100%	108%
Online Store	Reflector LED (BR20)	7	220	7,951	0.66	7,950	0.73	100%	110%
Online Store	Reflector LED (BR30)	10	5,979	360,115	35.87	360,085	32.88	100%	92%
Online Store	Reflector LED (BR30)	12	916	53,165	4.58	53,160	4.85	100%	106%
Online Store	Reflector LED (BR40)	9	233	14,288	1.40	14,288	1.30	100%	93%
Online Store	Reflector LED (R20)	6	50	2,409	0.20	2,409	0.22	100%	110%
Online Store	Reflector LED (R30)	9.5	783	47,583	4.70	47,585	4.35	100%	93%
Online Store	Reflector LED (PAR38)	17	151	7,937	0.76	7,937	0.72	100%	96%
Online Store	3-way LED	18	984	45,254	3.94	45,254	4.13	100%	105%
Online Store	Decorative LED	3.5	779	18,338	1.56	18,340	1.67	100%	108%
Online Store	Decorative LED	4	363	14,309	1.45	14,309	1.31	100%	90%
Online Store	Decorative LED	4.5	2,756	103,742	10.46	103,748	9.47	100%	91%
Online Store	Decorative LED	5	1,697	63,889	6.60	63,881	5.83	100%	88%
Online Store	Decorative LED	7	494	19,473	1.98	19,473	1.78	100%	90%
Online Store	Globe LED	5	48	1,840	0.19	1,840	0.17	100%	88%
Online Store	Globe LED	7.5	248	14,258	1.24	14,257	1.30	100%	105%
Online Store	Globe LED	10	227	12,428	1.14	12,428	1.14	100%	100%
Online Store	Linear LED	7	1	27	0.00	27	0.00	100%	83%
Online Store	Linear LED	8.5	12	112	0.01	112	0.01	100%	85%
Online Store	Linear LED	10	637	15,345	1.27	15,345	1.40	100%	110%
Online Store	Downlight LED Fixture	10	16	876	0.08	876	0.08	100%	100%
Online Store	Downlight LED Fixture	11	60	4,862	0.42	4,862	0.44	100%	106%
Online Store	Downlight LED Fixture	14	99	4,987	0.50	4,987	0.46	100%	92%
Online Store	Smart LED (A-Line)	9	44	1,590	0.13	1,638	0.15	103%	113%
Online Store	Smart LED (A-Line)	10	11	398	0.03	397	0.04	100%	110%
Online Store	Smart LED (BR30)	8	1	61	0.01	57	0.01	94%	87%
Online Store	Advanced Power Strip - Tier 1 (4-outlet)	N/A	48	4,934	0.58	2,712	0.30	55%	53%
Online Store	Advanced Power Strip - Tier 1 (7-outlet)	N/A	629	64,661	7.55	64,787	7.27	100%	96%

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Program Component	Measure Type	Wattage	Verified Units Sold	Ex-Ante Tracked Savings		Gross Revised Savings		Gross Savings RR (Before ISR)	
				KWH	KW	KWH	KW	KWH	KW
Online Store	Advanced Power Strip - Tier 1 (12-outlet)	N/A	171	17,579	2.05	17,613	1.98	100%	96%
Business Office Lighting	Standard LED	10	12,348	446,257	37.04	446,195	40.75	100%	110%
Business Office Lighting	Standard LED	12	4,116	184,808	16.46	184,788	16.88	100%	103%
Business Office Lighting	Standard LED	14	4,116	261,407	24.70	261,407	23.87	100%	97%
Low-Income Free LED Kits	Standard LED	10	11,560	417,778	34.68	417,721	38.15	100%	110%
Total			173,324	6,817,220	573.82	6,815,022	624.15	100%	109%

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ISR and Carryover Savings

Though customers put some bulbs purchased in storage for later use, research in other jurisdictions shows that most bulbs are installed within the first few years after purchase.⁶ The program-specific ISRs capture the first-year installation of program bulbs, and installation trajectories are employed to estimate later installation of program bulbs that were initially placed in storage. Advanced power strips are assigned an ISR of 100% and therefore excluded from carryover savings. Table 74 summarizes the first-year ISRs for each program based on participant surveys conducted in PY6 and PY7.

Table 74. LED Lighting ISR Results by Program

Program Component	ISR
Online Store (PY6 survey; n=288)	64%
Business Office Lighting (PY6 survey; n=100)	67%
Low-Income Free LED Kits (PY7 survey; n=240)	61%

The installation trajectory for bulbs purchased in PY6 assumed 98% of all bulbs purchased were installed in the first three years. Starting in PY7, the Evaluation Team shifted to an updated trajectory for carryover savings consistent with the latest update to the UMP that assumes 24% of any bulbs not installed in the first year will be installed in year two, 24% of bulbs remaining uninstalled after year two will be installed in year three, and 24% of bulbs remaining uninstalled after year three will be installed in year four. The updated trajectory results in diminishing marginal installations and claimable savings in each consecutive year after distribution until year four. For the sake of continuity, bulbs distributed in PY6 still use their originally assigned installation trajectory.

For PY6, the Evaluation Team used an ISR of 64% for the Online Store and 67% for the BOL offering, meaning another 34% of PY6 Online Store bulbs and 31% of PY6 BOL Store bulbs would be placed in storage and installed in the subsequent two years. This approach assumes that the remaining 2% of stored bulbs would not be installed. The PY6 installation trajectory assumes that of the bulbs placed in storage during year one, 55% are installed in year two and 45% are installed in year three.

For PY7, the Evaluation Team used an ISR of 64% for the Online Store, 67% for the BOL offering, and 61% for the Low-Income Free LED Kits offering. Therefore, 36% of bulbs received through the PY7 Online Store, 33% of bulbs received through the PY7 BOL offering, and 39% of bulbs distributed by the PY7 Low-Income Free LED Kits offering would be placed in storage. The PY7 installation trajectory assumes that 24% of bulbs remaining in storage are installed each year from year two through year four.

⁶ KEMA, Inc. The Cadmus Group, Inc. Itron, Inc., PA Consulting Group, Jai J. Mitchell Analytics, *Final Evaluation Report: Upstream Lighting Program*. Prepared for the California Public Utilities Commission, Energy Division. February 8, 2010

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The Evaluation Team estimated the carryover savings to be claimed in PY8 by multiplying verified gross and net savings from PY6 and PY7 by their associated PY8 carryover rates. PY6 Online Store and BOL savings were multiplied by 15% and 14%, respectively, to estimate PY6 savings claimable in PY8. PY7 Online Store, BOL, and Low-Income Free LED Kits savings were multiplied by 9%, 8%, and 9%, respectively, to estimate PY7 carryover savings claimable in PY8. Table 74 below provides the detailed trajectory for all bulbs distributed in PY6 or PY7 and installed in PY8.

Table 75. Lighting Program Carryover Savings Trajectories for Bulbs Distributed in PY6 and PY7

Program Year and Component	Carryover Savings Rate by Installation Year				
	PY6	PY7	PY8	PY9	PY10
PY6 Online Store	64%	34% x 55% = 19%	34% x 45% = 15%	N/A	
PY6 BOL	67%	31% x 55% = 17%	31% x 45% = 14%	N/A	
PY7 Online Store		64%	36% x 24% = 9%	27% x 24% = 6%	21% x 24% = 5%
PY7 BOL		67%	33% x 24% = 8%	25% x 24% = 6%	19% x 24% = 5%
PY7 Low-Income Free LED Kits		61%	39% x 24% = 9%	30% x 24% = 7%	21% x 24% = 5%

In PY9, savings from bulbs distributed in PY8 will be claimed as carryover. PY8 Online Store, BOL, and Low-Income Free LED Kits savings will be multiplied by 9%, 8%, and 9%, respectively, to estimate PY8 carryover savings claimable in PY9. Table 76 below provides the detailed trajectory for bulbs distributed in PY8.

Table 76. Lighting Program Carryover Savings Trajectories for Bulbs Distributed in PY8

Program Component	Carryover Savings Rate by Installation Year			
	PY8	PY9	PY10	PY11
Online Store	64%	36% x 24% = 9%	27% x 24% = 6%	21% x 24% = 5%
BOL	67%	33% x 24% = 8%	25% x 24% = 6%	19% x 24% = 5%
Low-Income Free LED Kits	61%	39% x 24% = 9%	30% x 24% = 7%	21% x 24% = 5%

NTGR Methods and Results

This section details the methodology the Evaluation Team used to calculate NTGRs for each program component. The NTGR represents the portion of the energy and demand savings associated with a program-supported measure or behavior change that would not have been realized in the absence of the program. In other words, the NTGR ratio represents the share of program-induced savings. The NTGR ratio consists of FR and spillover. FR is the proportion of the program-achieved verified gross savings that would have been realized absent the program. Spillover occurs when participants take additional energy-saving actions that are influenced by program interventions but did not receive program support.

For the Online Store and Business Office Lighting offerings, the Evaluation Team relied on FR and spillover estimated as part of the PY6 evaluation. For the Low-Income Free LED Kits offering, the Evaluation Team relied on FR and spillover estimated based on a participant survey of PY7 Low Income Free LED Kits recipients. The final NTGR for each program component was calculated using the equation provided below.

$$NTGR = (1 - FR) + Spillover$$

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Table 77 provides a summary of FR, spillover, and final NTGRs for each offering. As can be seen in the table, the final NTGR is 0.73 for the Online Store, 0.83 for the BOL component, and 0.95 for the Low-Income Free LED Kits offering, all in line with values applied in PY7.

Table 77. Lighting Program Final NTGR Summary

Estimate	Online Store	Business Office Lighting	Low-Income Free LED Kits
FR	0.29	0.22	0.14
Spillover	0.02	0	0.03
NTGR	0.73	0.83	0.95

Appendix C. Heating and Cooling Program Detailed Methods

Heating & Cooling Equipment Deemed Savings Values

The Evaluation Team applied the pre-determined deemed per-ton savings values from previous program years for measures that existed prior to PY8 but incented in PY8. The Evaluation Team developed per-ton deemed savings values for new measures in PY8 using the same methodology as detailed in the PY6 Evaluation Report. Table 78 summarizes the ex-ante and ex-post deemed savings values for each PY8 Heating & Cooling Equipment measure.

Table 78. Heating & Cooling Equipment Ex-Ante and Ex-Post Deemed Per-Ton Savings

Measure	Ex-Ante		Ex-Post	
	KWH/Ton	KW/Ton	KWH/Ton	KW/Ton
CAC				
SF - Packaged - Furnace/AC - SEER 15	99.64	0.083	99.64	0.083
SF - Split - Furnace/AC - SEER 15	110.96	0.094	110.96	0.094
SF - Packaged - Furnace/AC - SEER 16	148.81	0.124	148.81	0.124
SF - Split - Furnace/AC - SEER 16	160.93	0.135	160.93	0.135
SF - Packaged - Furnace/AC - SEER 17 ¹	148.81	0.124	190.56	0.157
SF - Split - Furnace/AC - SEER 17	188.72	0.156	188.72	0.156
SF - Split - Furnace/AC - SEER 18	201.45	0.162	201.45	0.162
SF - Split - Furnace/AC - SEER 19	230.41	0.183	230.41	0.183
SF - Split - Furnace/AC - SEER 20	296.59	0.237	296.59	0.237
SF - Split - Furnace/AC - SEER 21 ²	296.59	0.237	295.49	0.230
SF - Split - Furnace/AC - SEER 22 ¹	296.59	0.237	296.76	0.226
SF - Split - Furnace/AC - SEER 23 ¹	296.59	0.237	317.80	0.238
SF - Split - Furnace/AC - SEER 25 ¹	296.59	0.237	319.31	0.224
SF - Split - Furnace/AC - SEER 26 ¹	296.59	0.237	332.61	0.228
ASHP				
SF - Split - ASHP - SEER 15	283.93	0.240	283.93	0.240
MH - Packaged - ASHP - SEER 15	191.86	0.147	191.86	0.147
SF - Packaged - ASHP - SEER 15	299.94	0.256	299.94	0.256
SF - Split - ASHP - SEER 16	382.12	0.275	382.12	0.275
MH - Packaged - ASHP - SEER 16 ¹	191.86	0.147	409.16	0.280
MH - Split - ASHP - SEER 16 ¹	178.26	0.070	409.25	0.281
SF - Packaged - ASHP - SEER 16	382.51	0.276	382.51	0.276
SF - Split - ASHP - SEER 17	464.24	0.361	464.24	0.361
SF - Split - ASHP - SEER 18	506.73	0.414	506.73	0.414
MH - Split - ASHP - SEER 18 ¹	250.95	0.100	540.82	0.422
SF - Split - ASHP - SEER 19	543.93	0.457	543.93	0.457
SF - Split - ASHP - SEER 20	518.05	0.451	518.05	0.451
SF - Split - ASHP - SEER 21	713.64	0.598	713.64	0.598
SF - Split - ASHP - SEER 22	689.96	0.586	689.96	0.586
SF - Split - ASHP - SEER 23	669.16	0.572	669.16	0.572
SF - Split - ASHP - SEER 24 ¹	773.20	0.430	798.27	0.648

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Measure	Ex-Ante		Ex-Post	
	KWH/Ton	KW/Ton	KWH/Ton	KW/Ton
SF - Split - ASHP - SEER 25	689.80	0.579	689.80	0.579
SF - Split - ASHP - SEER 26	718.53	0.591	718.53	0.591
SF - Split - ASHP - SEER 27	745.13	0.598	745.13	0.598
SF - Split - ASHP - SEER 29 ¹	745.13	0.598	792.83	0.598
SF - Split - ASHP - SEER 30 ¹	745.13	0.598	814.29	0.591
DFHP				
SF - Split - DFHP - SEER 15	191.86	0.147	191.86	0.147
SF - Split - DFHP - SEER 16	430.90	0.310	430.90	0.310
SF - Packaged - DFHP - SEER 16	269.66	0.195	269.66	0.195
SF - Split - DFHP - SEER 17	465.88	0.363	465.88	0.363
SF - Split - DFHP - SEER 18	399.34	0.337	399.34	0.337
SF - Split - DFHP - SEER 20	844.58	0.681	844.58	0.681

¹ New PY8 measure. The Evaluation Team calculated deemed savings as part of the PY8 evaluation for these measures. The TRM Lite will be updated to reflect these additions.

² TRM Lite values were available, but Implementation Team applied different values

Ductwork Deemed Savings Values

Table 79 compares the ex-ante and ex-post deemed savings values for each PY8 ductwork measure. The ex-ante and ex-post deemed values for ductwork measures are identical.

Table 79. Ductwork Ex-Ante and Ex-Post Savings Per-Ton Comparison

Measure	Ex-Ante		Ex-Post	
	KWH/Ton	KW/Ton	KWH/Ton	KW/Ton
Complete Duct Replacement (HP)	612.00	0.159	612.00	0.159
Complete Duct Replacement (AC)	342.00	0.159	342.00	0.159
Duct Sealing (HP)	362.45	0.103	362.45	0.103
Duct Sealing (AC)	221.90	0.103	221.90	0.103
Duct Insulation (HP)	249.60	0.056	249.60	0.056
Duct Insulation (AC)	120.10	0.056	120.10	0.056

Heating & Cooling Equipment NTGR Detail

The Evaluation Team presents below the detailed methods for deriving the PY8 and prospective PY9 NTGR for Heating & Cooling Equipment. In April 2018, the program increased its rebates for Heating & Cooling Equipment. As such, the Evaluation Team conducted a participant and contractor survey to determine whether these changes have affected program influence. The results of the surveys were used to calculate a NTGR for projects that occurred after the rebate change. The Evaluation Team applied the PY6 NTGR for projects that occurred before the rebate change (before April 2nd) and a new NTGR based on PY8 survey results for projects after the rebate change. The two NTGRs were then weighted by the proportion of ex-post gross savings they represent to establish an overall NTGR for PY8. Moving forward, the Evaluation Team will apply the post-rebate NTGR in PY9.

The Evaluation Team developed a participant FR score for each participant in the PY8 survey. This score measured the influence of the rebate and contractor recommendations on customers' decisions to install

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high-efficiency HVAC units. It also measured the rebate and the contractor recommendation's influence on the efficiency level they chose, the timing of their purchase, and the number of HVAC systems they purchased.

Each step in calculating the participant FR score is explained below. Importantly, the Evaluation Team converted these components into scores between 0 and 1, where 0 is "not at all a free rider" (highest program influence) and 1 is "a complete free rider" (no program influence).

Step 1: Determine the rebate's influence on customers

The Evaluation Team first asked participants about their likelihood of purchasing a new HVAC unit at all if the rebate had not been available, on a 0-10 scale from "not at all likely" to "extremely likely". Respondents who were not likely to purchase a new HVAC unit at all without the rebate (likelihood of "3" or below) automatically received an FR score of 0. Respondents who indicated that they learned about the rebate after their new HVAC unit had already been installed automatically received a FR score of 1.

For all other participants surveyed in PY8, the Evaluation Team developed a rebate influence score based on the following components:

- **Efficiency Influence (E)** Measures the likelihood the participant would have purchased an HVAC unit that was as efficient as the unit they installed if the rebate had not been available (0-10 scale from "not at all likely" to "extremely likely"). The higher the likelihood, the higher the FR score.
- **Timing Influence (T)** Adjusts the FR score downwards if the rebate caused the participant to purchase their new equipment earlier than they would have without the rebate.
- **Quantity Influence (Q)** Adjusts the rebate free-ridership score downwards if the participant would have purchased fewer HVAC units without the rebate.

$$\text{Rebate Free Ridership (Rebate FR)} = E * T * Q$$

After calculating the individual Rebate FR scores, the Evaluation Team developed a weighted average score that gives more weight to projects with more savings. The resulting Rebate FR score was 0.65 for both KWH and KW.

Step 2: Adjust for contractor influence on customers

Each of the 339 post-rebate change respondents received a contractor recommendation FR score between 0 and 1, where 0 is "not at all a free rider" (highest contractor influence) and 1 is "a complete free rider" (no contractor influence).

- The majority (308 of 339, or 91%) received recommendations from the contractor on the type of equipment to install. Of those 308 respondents, 90% received recommendation for a specific type of HVAC unit to install and 91% received a recommendation for a high efficiency unit. According to PY5 evaluation results, 73% of contractors surveyed (n=54) reported that customers take their recommendation all or most of the time. Thus, the Evaluation Team assumed these respondents went with their contractor's recommendation and assigned maximum contractor influence (Contractor Recommendation FR=0).
- A small number of respondents (18 of 339, or 5%) did not receive any recommendation at all and the Evaluation Team assigned them no contractor recommendation influence (Contractor Recommendation FR=1).

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- The remaining respondents (13 of 339, or 4%) reported that they did not receive a specific equipment or high efficiency recommendation but were recommended to replace instead of repairing their existing system. Assuming these customers has some level of contractor recommendation influence, the Evaluation Team calculated a contractor recommendation FR score for this subgroup. The Evaluation Team assessed the influence of contractors' recommendations in the same manner as the Rebate FR score in Step 1 but using contractor-related survey questions instead.

The Evaluation Team adjusted the rebate FR score based on the participant's contractor recommendation FR score. The Evaluation Team set the rebate FR score to 0 for those respondents who were highly influenced by their contractor (Contractor Recommendation $FR < 0.4$) to calculate the Adjusted FR score. The Evaluation Team weighted the Adjusted FR score to give more weight to projects with more savings. The resulting post-rebate change Adjusted FR score was 0.02 for KWH and 0.02 for KW. The difference between the Rebate FR and Adjusted FR score represents the Total Contractor Influence (0.63 for both KWH and KW).

Step 3: Determine program influence on contractors

Next, it is necessary to account for how much of the Total Contractor Influence is indirectly due to the program's support of contractors and the rebate's usefulness as a sales tool. Thus, for each contractor in the PY8 survey, the Evaluation Team developed a Contractor Free-Ridership (CFR) score based on the following components.

- **Program Rebate Influence (PR):** The Evaluation Team assessed the influence of the program rebate on contractors from three perspectives:
 - **New HVAC Influence (RR):** Measures how likely contractors were to have recommended HVAC options of SEER 15 or higher (program-eligible equipment in PY8) to participants if the rebate had not been available (0-10 scale from "not at all likely" to "extremely likely"). A higher likelihood to recommend high-efficiency options without the rebate indicates higher FR.
 - **Efficiency Level Influence (RE):** Measures the likelihood the contractor would have recommended HVAC unit that was as efficient as the HVAC unit they installed if the rebate had not been available. Contractors who would have recommended slightly lower or much lower efficiency were given lower FR scores.
 - **Sales Tool Influence (RS):** Measures how influential the rebate was in conversations where the contractor convinced a customer to install a new HVAC unit, rather than fix the existing unit (0-10 scale from "not at all influential" to "extremely influential"). Contractors who found the rebate to be helpful as a sales tool were given lower FR scores.

$$CFR = RR * \text{Minimum}(RE, RS)$$

Notably, to avoid overestimating program influence, the CFR score does not credit the contractor with both efficiency and sales tool influence, rather it selects the component with the lowest FR.

Finally, once the Evaluation Team calculated the individual CFR scores, the Evaluation Team developed a weighted average score that gives more weight to contractors with more projects and savings through the program. The resulting CFR score was 0.51 for both KWH and KW. This means that 51% of contractor influence is *not* attributable to program and, conversely, 49% is attributable. The Evaluation Team applied the 49% of Total Contractor Influence to the post-rebate participant FR score. The resulting credit was 0.31 for both KWH and KW.

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Step 4: Determine the Final FR score

The Evaluation Team applied the credits to the post-rebate FR score of 0.63 for both KWH and KW. The resulting Final FR scores were 0.35 (KWH and KW) for post-rebate change projects.

Step 5: Determine Spillover

Spillover savings are based on participant survey respondents who were highly influenced to install additional energy-efficient measures not rebated or recommended by the program. From the 497 surveyed participants (339 post-rebate change and 158 pre-rebate change), 50 participants (10%) installed additional measure eligible for spillover savings.

The main sources used to determine spillover savings are the South Carolina Measure Database (SCMDB), recommended deemed savings from other DESC programs (e.g., NEEP, HEC, ARP, Ductwork, Online Store), and relevant TRMs such as the Illinois TRM.⁷ Table 80 summarizes the per-measure savings for each identified spillover measure.

Table 80. Heating & Cooling Equipment Deemed Per-Unit Spillover Savings

Measure	Units	KWH/Unit	KW/Unit	Source
Heat Pump Water Heater	Water Heaters	1,265.79	0.060	IL TRM V7.0
Recycled Refrigerator	Refrigerators	1,069.15	0.122	PY8 ARP Evaluation
Water Heater Tank Wrap	Blankets	360.80	0.041	PY6 HEC Evaluation
Seal & Insulate Ducts (HP)	Tons	267.52	0.070	PY5 Ductwork Evaluation w/ 44% Adjustment Factor
Low Flow Aerator (Kitchen)	Aerators	225.00	0.011	IL TRM V7.0
Seal Ducts (HP)	Tons	158.43	0.046	PY5 Ductwork Evaluation w/ 44% Adjustment Factor
ENERGYSTAR Window AC	Window ACs	153.63	0.028	IL TRM V7.0
Low Flow Showerhead	Showerheads	151.73	0.008	IL TRM V7.0
Seal & Insulate Ducts (AC)	Tons	149.50	0.070	PY5 Ductwork Evaluation w/ 44% Adjustment Factor
Weather-stripping (15% Improvement HP)	kSF CFA	136.96	0.019	SCMDB
Water Heater Temperature Adjustment	Water Heaters	113.84	0.013	PY5 NEEP Evaluation
Insulate Ducts (HP)	Tons	109.11	0.025	PY5 Ductwork Evaluation w/ 44% Adjustment Factor
Seal Ducts (AC)	Tons	97.00	0.046	PY5 Ductwork Evaluation w/ 44% Adjustment Factor
Weather-stripping (10% Improvement HP)	kSF CFA	91.27	0.013	SCMDB
LEDs (Exterior)	Bulbs	81.68	0.003	PY8 Online Store Evaluation
Advanced Power Strip	Power Strips	80.00	0.009	IL TRM V7.0
Replace Filters (HP)	Participants	64.00	0.015	PY6 NEEP Evaluation
Attic Insulation	kSF CFA	60.16	0.033	SCMDB
Wall Insulation	kSF Wall Area	57.88	0.034	SCMDB
HVAC Tune-Up (HP)	Tons	44.87	0.045	SCMDB
HVAC Tune-Up (AC)	Tons	41.46	0.044	SCMDB

⁷ The Evaluation Team used the IL TRM Version 7.0, Volume 3: Residential Measures

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Measure	Units	KWH/Unit	KW/Unit	Source
Weather-stripping (15% Improvement AC)	kSF CFA	40.33	0.020	SCMDB
LEDs (Interior)	Bulbs	36.14	0.003	PY8 Online Store Evaluation
Window Air Conditioner Cover	AC Covers	34.35	-	PY6 NEEP Evaluation
Replace Filters (AC)	Participants	32.00	0.018	PY6 NEEP Evaluation
ENERGYSTAR Ventilation Fan	Fans	27.40	0.003	IL TRM V7.0
Weather-stripping (10% Improvement AC)	kSF CFA	26.48	0.014	SCMDB
Low Flow Aerator (Bathroom)	Aerators	24.00	0.003	IL TRM V7.0
Water Heater Pipe Insulation	Linear Feet	13.72	0.002	PY6 NEEP Evaluation
Crawl Space Insulation	kSF Crawlspace Area	-88.06	-0.021	SCMDB

Note: kSF CFA is per 1,000 square feet of conditioned floor area

Approximately half (44%) of KWH spillover savings are due to improvements to ducts (i.e., duct insulation, duct sealing, duct replacement). Therefore, the Evaluation Team used information from follow-up calls to adjust duct improvement savings accordingly. Participants identified received rebates in PY9 (n=2), performed insignificant improvements to duct work (n=4), replaced half of existing duct work (n=1), performed duct sealing only when survey results suggested both duct sealing and insulation (n=1), or confirmed significant improvements to duct work (n=1). This feedback led to the development of a 44% adjustment factor for all duct improvement spillover savings.

The majority (76%) of KW savings are driven by duct improvements (46%) and HVAC tune-ups (30%). Additionally, DESC circulated "Thank-You" cards to participants which included several energy savings recommendations. Interestingly, 19% and 35% of KWH and KW spillover savings are influenced by the distribution of the "Thank You" cards, respectively. The total spillover savings for the HVAC program are summarized in Table 81 below.

Table 81. Heating & Cooling Equipment Spillover Savings Summary

Measure	Total KWH	Total KW
Seal & Insulate Ducts (HP)	7,344	1.91
Seal & Insulate Ducts (AC)	5,130	2.39
Heat Pump Water Heater	3,797	0.18
Attic Insulation	3,451	1.88
Seal Ducts (HP)	3,262	0.93
LEDs (Exterior)	3,104	0.13
Weather-stripping (HP)	2,830	0.39
Wall Insulation	2,105	1.22
HVAC Tune-Up (HP)	2,019	2.02
Water Heater Tank Wrap	1,443	0.16
LEDs (Interior)	1,373	0.13
Seal Ducts (AC)	1,331	0.62
Recycled Refrigerator	1,069	0.12
HVAC Tune-Up (AC)	871	0.93
Water Heater Temperature Adjustment	797	0.09

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Measure	Total KWH	Total KW
Weather-stripping (AC)	772	0.39
Low Flow Showerhead	759	0.04
Insulate Ducts (HP)	749	0.17
Low Flow Aerator (Kitchen)	225	0.01
Window Air Conditioner Cover	206	0.00
Water Heater Pipe Insulation	165	0.02
ENERGYSTAR Window AC	154	0.03
Advanced Power Strip	80	0.01
Low Flow Aerator (Bathroom)	72	0.01
Replace Filters (AC)	64	0.04
Replace Filters (HP)	64	0.02
ENERGYSTAR Ventilation Fan	55	0.01
Crawl Space Insulation	-3,038	-0.72
Total	28,148	9.55
Total Ex-Post Savings for Surveyed Sample (n=497)	434,856	348.53
% Spillover	6.47%	2.74%

Step 6: Determine the Final NTGRs

The Evaluation Team applied the credits to the Rebate FR scores of 0.65 for both KWH and KW and the resulting Final FR scores were 0.35 for both KWH and KW. The Evaluation Team then added in spillover values from the PY8 participant survey and calculated the NTGR using the following formula:

$$NTGR = 1 - FR + Spillover$$

The resulting NTGR for post-rebate change projects was 0.72 for KWH energy savings and 0.68 for KW demand savings. The pre-rebate change NTGRs of 0.55 (KWH) and 0.48 (KW) were derived from the PY6 evaluation. Table 82 summarizes each step of the calculation to arrive at the pre- and post-rebate change NTGRs.

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Table 82. Heating & Cooling Equipment NTGR Calculation Steps

Step	Value	Component	Pre-Rebate Change Score		Post-Rebate Change Score		FR Standard Deviation (unweighted)	FR Relative Precision at the 90% Confidence Level
			KWH	KW	KWH	KW		
Step 1: Determine the rebate's influence on customers	A	Rebate Influence FR Score	0.73	0.82	0.65	0.65	Pre-rebate change: 0.29 Post-rebate change: 0.002	Pre-rebate change: 3% Post-rebate change: N/A
Step 2: Adjust for contractor influence on customers	B	Adjusted FR Score	0.13	0.01	0.02	0.02	N/A	N/A
	C	Total Contractor Influence	0.60	0.81	0.63	0.63	N/A	N/A
Step 3: Determine program influence on contractors	D	CFR Score	0.62	0.62	0.51	0.51	Pre-rebate change: 0.17 Post-rebate change: 0.23	Pre-rebate change: 2% Post-rebate change: 0.02%
	E	% of Contractor Influence Attributable to Program (1 - D)	0.38	0.38	0.49	0.49	N/A	N/A
	F	Credit to Participant Score from Contractor Influence (C * E)	0.22	0.30	0.31	0.31	N/A	N/A
Step 4: Determine final FR Score	G	Final FR Score (A - F)	0.50	0.52	0.35	0.35	N/A	N/A
Step 5: Add SO	H	SO	0.05	0.00	0.06	0.03	N/A	N/A
	I	NTGR (1 - G + H)	0.55	0.48	0.72	0.68	N/A	N/A

Note: Some values in this table do not sum or divide exactly due to rounding.

The Evaluation Team weighted the pre- and post-rebate change NTGRs by the proportion of ex-post savings they represent to establish an overall NTGR for PY8. Table 83 shows the final weighted NTGR for PY8. For PY9, the Evaluation Team recommends the post-rebate change NTGRs (0.72 for KWH and 0.68 for KW) as they align with the new incentive structure.

Table 83. Heating & Cooling Equipment PY8 NTGRs

Measure	Ex-Post Gross Savings		NTGR	
	KWH	KW	KWH	KW
Pre-Rebate Change	143,528	115	0.55	0.48
Post-Rebate Change	291,328	234	0.72	0.68
Overall for PY8	434,856	349	0.66	0.62

Appendix D. Home Energy Check-up Detailed Methods

Detailed ISR Findings

The Evaluation Team developed ISRs based on PY8 participant survey results. Table 84 shows the ISRs for each leave-behind or direct install measure. The ISR analysis excluded a small number of customers who “did not know” how many measures they received or installed.

Table 84. HEC ISRs Summary

Measures	Measures Verified as Received	Measures Verified as Installed	ISR
LED Bulb	2,327	1,712	74%
Faucet Aerator	43	42	98%
Hot Water Pipe Insulation (feet)	70	49	70%
Electric Water Heater Insulating Blanket	97	59	61%

NTGR Findings

Gross impacts are the change in energy consumption (or demand) that results directly from program-related actions taken by program participants, regardless of why they took those actions. Net impacts are defined as the change in consumption that can be attributed to the program. Net impacts may be lower than total program gross impacts due to energy savings that would have occurred in the absence of the program FR. Conversely, the net impacts may be higher than total program gross impacts due to energy impacts that occurred because of the program but were not incented by the program (spillover).

The PY8 evaluation explored NTGRs for leave-behind and recommended measures amongst PY8 participants. Program net impacts are expressed as a NTGR that takes into account two factors: self-reported FR and spillover. FR represents the percentage of savings achieved had a customer not participated in the program. FR has a number between 0 and 1, with 1 being a 100% free rider. Spillover represents additional savings that were achieved without program incentives but would not have occurred without the program. Spillover savings are represented as a percentage of gross savings from the program. The Evaluation Team calculate separate NTG ratios for leave-behind and recommended measures. Each NTGR is calculated as:

$$NTGR = 1 - FR + Spillover$$

The evaluation derived FR and spillover estimates using the PY8 participant survey, which asked a battery of structured questions about the influence of the program on the decision to install energy-efficient equipment. Below is the algorithm for estimation of the NTGRs based on these surveys. This section further describes the methodology to estimate FR, as well as spillover, and presents the final program NTGRs.

Leave-Behind Measures Free-Ridership

The Evaluation Team calculated an FR score for each measure as follows:

- **Program Likelihood (L):** The Evaluation Team asked participants to rate the likelihood of purchasing the leave-behind measures if they had not received them through the program (0-10 scale where 10 is “extremely likely”). Based on the response, the Evaluation Team generated a likelihood score between 0 and 1 (response divided by 10). Respondents who were more likely to have purchased the measure in absence of the program received a higher PI score than those who were not as likely.

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If the respondent rated the likelihood of purchasing LEDs in the absence of the program as 5 or higher, the Evaluation Team explored the possibility of other forms of program influence:

- **Program Timing (T):** The program's impact on the timing of measure installation is measured by asking participants if they would have installed the measure later without the program and, if so, how much later. Those who were influenced to install the measure earlier were credited with additional program influence.
- **Program Quantity (Q):** For LEDs only, the Evaluation Team also asked respondents if they would have purchased the same number or fewer LEDs without the program. Those who would have installed fewer were credited with some additional program influence.

Using these factors, the Evaluation Team calculated the FR score as follows:

$$\text{Free-ridership} = L * T * Q$$

The Evaluation Team established measure-specific FR scores based on the savings-weighted average of individual FR scores. To establish one overall FR score for all leave-behind measures, the Evaluation Team weighted the FR scores for LEDs, faucet aerators, pipe insulation and water heater blankets to reflect the proportion of ex-post savings they represent. Table 85 shows the FR scores for each measure, as well as the combined FR score for all leave-behind measures.

Table 85. HEC Leave-behind Measures FR Summary

Leave-behind Measure Type	FR		% of Savings	
	KWH	KW	MWH	MW
Kit of 5 LEDs (n=437)	0.51	0.51	67%	68%
Faucet Aerator (n=42)	0.32	0.32	12%	7%
Hot Water Pipe Insulation - 6 feet (n=49)	0.39	0.39	4%	5%
Electric Water Heater Insulating Blanket (n=59)	0.35	0.35	17%	21%
Overall leave-behind measures (Weighted)	0.46	0.46	100%	100%

Note: Base only includes respondents who recall installing the measure

Recommended Measures FR

FR for recommended measures is based on the self-reported influence of the program on respondents' decisions to take those measures. The Evaluation Team determined FR based on the proportion of savings from recommended measures represented by those who were highly influenced by the program (score of 8 or higher on a scale from 0 to 10, where 10 is "extremely influential").

Table 86. HEC Recommended Measures FR Summary

Calculation Step		KWH	KW
A	Recommended measures savings among respondents with influence score ≥ 8	94,785	19.17
B	Recommended measures savings across all respondents	139,191	25.59
C (A/B)	Recommended measures NTGR	0.68	0.75
D (1-C)	Recommended measures FR	0.32	0.25

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Spillover

Spillover savings are based on participant survey respondents who were highly influenced to install additional energy-efficient measures not rebated or recommended by the program. From the 497 surveyed participants, 48 participants installed additional measures eligible for spillover savings.

The main sources used to determine spillover savings are the South Carolina Measure Database (SCMDB), recommended deemed savings from other DESC programs (e.g., NEEP, HVAC, ARP, Ductwork, Online Store), and relevant TRM such as the Illinois TRM.⁸ Table 80 summarizes the per-measure savings for each identified SO measure.

Table 87. HEC Deemed Per-Measure Spillover Savings

Measure	Qty	Units	KWH/Unit	KW/Unit	Source ^a
Pool Pump	1	Pumps	2,340.27	1.125	ENERGYSTAR Pool Pump Calculator (2013)
Pool Pump Timer	2	Participants	1,180.00	-	Custom calculation
Recycled Refrigerator	6	Refrigerators	1,069.15	0.122	PY8 ARP Program AVGs
Recycled Freezer	4	Freezers	738.91	0.084	PY8 ARP Program AVGs
ENERGYSTAR Clothes Dryer	4	Clothes Dryers	160.44	0.022	Illinois TRM V7.0
ENERGYSTAR Window Air Conditioner (WAC)	2	Participants	153.63	0.028	Illinois TRM V7.0
Low-flow Showerhead	17	Showerheads	132.77	0.008	Illinois TRM V7.0
ENERGYSTAR Refrigerator	3	Refrigerators	94.00	0.016	SCMDB average for top freezer and side by side
ENERGYSTAR Clothes Washer	3	Clothes Washers	80.80	0.012	Illinois TRM V7.0
Advanced Power Strips (APS)	31	Power strips	80.00	0.009	Illinois TRM V7.0; Deemed savings for Tier 1 Direct Install APS' with unknown number of outlets
ENERGYSTAR Ceiling Fan	6	Ceiling fans	64.49	0.031	South Carolina Measures Database (SCMDB)
Exhaust Fan	6	Fans	27.40	0.003	Illinois TRM V7.0
Basement Wall Insulation	0.81	1,000 sq ft basement wall area	- 11.27	0.002	SCMDB
Floor Insulation	3.50	1,000 sq ft floor area	- 73.49	- 0.009	SCMDB
Crawlspace Wall Insulation	8.65	1,000 sq ft crawlspace area	- 88.06	- 0.021	SCMDB

^a Custom calculations for pool pump timer are based on information gathered from participant call-backs conducted in PY6.

The total spillover savings for the DESC PY8 HEC program are summarized in the table below. The majority of spillover savings come from recycled appliances (47%), more efficient pool pumps and pool pump timers (24%), and advanced power strips (13%). Note that the Evaluation Team confirmed that all recycled appliances included in spillover did not participate in DESC's PY8 Appliance Recycling Program.

⁸ The Evaluation Team used the IL TRM Version 7.0, Volume 3: Residential Measures

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Table 88. HEC Spillover Summary

Measure	Total KWH	Total KW
Recycled Refrigerator	6,415	0.73
Recycled Freezer	2,956	0.34
Advanced Power Strips (APS)	2,480	0.28
Pool Pump Timer	2,360	-
Pool Pump	2,340	1.13
Low-flow Showerhead	2,257	0.14
ENERGYSTAR Clothes Dryer	642	0.09
ENERGYSTAR Ceiling Fan	387	0.19
ENERGYSTAR Window Air Conditioner (WAC)	307	0.06
ENERGYSTAR Refrigerator	282	0.05
ENERGYSTAR Clothes Washer	242	0.03
Exhaust Fan	164	0.02
Basement Wall Insulation	-9	0.00
Floor Insulation	-257	(0.03)
Crawlspace Wall Insulation	-762	(0.18)
Total	19,805	2.84
<i>Total Ex-Post Savings for Surveyed Sample (n=497)</i>	<i>248,197</i>	<i>35.71</i>
% Spillover	8.0%	7.9%

HEC Program NTGR

The Evaluation Team determined the program's overall NTGR by taking the weighted average of each component NTGR based on gross and net ex-post savings. Table 89 below provides an overview of the component-level and program-overall NTG ratios.

Table 89. HEC NTGR Summary

Component	FR		Spillover		NTG (1 – FR + Spillover)	
	KWH	KW	KWH	KW	KWH	KW
Leave-Behind Measures	0.46	0.46	0.08	0.08	0.62	0.62
Recommended Measures	0.32	0.25	0.08	0.08	0.76	0.83
Overall Program (Savings-Weighted)	0.38	0.31	0.08	0.08	0.70	0.77

Recommended Measure Savings

DESC representatives provided a list of low-cost, energy-efficient measures to all HEC participants to help further reduce energy consumption. The Evaluation Team calculated gross and net savings from recommended measures using PY8 survey response data from 497 HEC participants. Survey results reported that 81% of participants (401 of 497 survey respondents) indicated implementing one or more of the recommended measures. Table 90 summarizes the number of participants who installed recommended measures.

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Table 90. HEC Recommended Measure Participation Overview for Gross Savings

Recommended Measure	Number of Surveyed Participants	% of Surveyed Participants (n=497)
Caulk, seal and weather-strip windows or doors	115	23%
Repair ducts	94	19%
Have central heating and cooling system serviced	89	18%
Install LEDs	60	12%
Install programmable thermostat	58	12%
Attic Insulation	41	8%
Replace air filters	41	8%
Adjust water heater temperature to 120 °F	30	6%

Deemed Savings Assumptions

Table 91 summarizes the per-measure savings for each recommended measure.

Table 91. HEC Deemed Per-Measure Recommended Measure Savings

Recommended Measure	Units	KWH per Unit Savings	KW per Unit Savings
Seal and insulate ducts (HP)	Per participant	802.55	0.211
Programmable thermostat (HP)	Per 1,000 sf of Conditioned Floor Area	555.18	- 0.134
Seal ducts (HP)	Per participant	475.30	0.137
Seal and insulated ducts (CAC)	Per participant	448.49	0.211
Insulate ducts (HP)	Per participant	327.32	0.074
Seal ducts (CAC)	Per participant	290.99	0.137
Programmable thermostat (CAC)	Per 1,000 sf of Conditioned Floor Area	204.94	- 0.068
Insulate ducts (CAC)	Per participant	157.49	0.074
Weather-strip (15% infiltration reduction) HP	Per 1,000 sf of Conditioned Floor Area	136.96	0.019
HVAC tune-up (HP)	Per participant	134.62	0.134
HVAC tune-up (CAC)	Per participant	124.39	0.133
Adjust Water Heater Temperature	Per water heater	113.84	0.013
Weather-strip (10% infiltration reduction) HP	Per 1,000 sf of Conditioned Floor Area	91.27	0.013
Install LEDs (exterior)	Per lamp	81.68	0.003
Replace air filters (Electric Furnace & CAC)	Per participant	64.00	0.015
Replace air filters (HP)	Per participant	64.00	0.015
Attic insulation	Per 1,000 sf of Conditioned Floor Area	60.16	0.033
Weather-strip (15% infiltration reduction) A/C	Per 1,000 sf of Conditioned Floor Area	40.33	0.020
Install LEDs (interior)	Per lamp	36.14	0.003
Replace air filters (CAC Only)	Per participant	32.00	0.018
Weather-strip (10% infiltration reduction) A/C	Per 1,000 sf of Conditioned Floor Area	26.48	0.014

Table 92 outlines the assumptions used to derive the per-measure savings presented in Table 91.

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Table 92. HEC Assumptions Used to Calculate Per-Measure Savings

Recommended Measure	Assumptions
Install a programmable thermostat	Used home's actual square footage reported in HEC PY8 tracking database; if unknown, applied average square footage from those with known values; SCMDB for moderate setback, applied based on HVAC type.
Repair ducts	Applied recommended duct sealing, duct insulation, and duct replacement values; applied based on HVAC type; applied 44% adjustment factor based on information gathered from call backs from PY8 HVAC Program spillover participants.
Replace air filters	Applied recommended air filter savings value; applied based on HVAC type.
Have central heating and cooling system serviced	Applied recommended per-ton savings for 5% improvement; Applied per-ton savings based on average tonnage (3 tons) from DESC's Heating & Cooling Program; savings applied based on HVAC type
Adjust water heater temperature	Applied recommended temperature adjustment savings value
Caulk, seal and weather-strip windows or doors	Used home's actual square footage reported in HEC PY8 tracking database; if unknown, applied average square footage from those with known values; SCMDB value for either 10% or 15% reduction (depending on survey response); applied based on HVAC type.
Upgrade attic insulation to a minimum of R-38	Used home's actual square footage reported in HEC PY8 tracking database; if unknown, applied average square footage from those with known values; SCMDB value based on HVAC type.
Install LEDs	Applied recommended LED savings value consistent with LEDs from other DESC programs (BOL, Residential Lighting, HEC leave-behind kits) for those installed in interior; Calculated LED savings for exterior using same methodology to calculate Residential Lighting program measure savings

Savings for three of the recommended measures were not quantified for the reasons described in Table 93.

Table 93. HEC Excluded Recommended Measures

Excluded Recommended Measure	Reasoning
Leave interior doors open and keep vents open for adequate air flow	This recommendation could yield increased energy use depending on the home. There have been cases where it is recommended to close doors and vents to unused rooms so that only occupied rooms are being conditioned. This decreases the air volume for heating or cooling, thus decreasing the amount of energy consumed. However, there are too many unknown variables to quantify these savings. Savings for this measure require custom-level calculations and depend on thermostat location, home size, occupancy, vent location, and HVAC type, size, age and operating schedules.
Unplug appliances, lights, TVs, computers, etc. when not in use	The Evaluation Team cannot be sure that the unplugged appliances have "phantom" loads and whether the behavior has been sustained over time.
Set thermostat manually at 68°F or lower in the winter and 78°F or higher in the summer	The type of thermostat the participant uses is unknown, as is whether the behavior has been sustained over time.

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Gross Savings

Table 94 summarizes the total calculated recommended measure ex-post gross savings. The Evaluation Team divided the total recommended measure savings by the total number of surveyed participants (n=497) to determine the average gross savings per participant.

Table 94. HEC Total and Per Participant Recommended Measure Gross Savings

Recommended Measure	Total Ex-Post Gross Savings from Measure		Ex-Post Gross Savings per Participant*	
	KWH	KW	KWH	KW
Repair ducts	45,518	16.00	484.24	0.17
Install programmable thermostat	38,543	(10.58)	664.53	(0.18)
Install LEDs	20,806	1.38	346.77	0.02
Caulk, seal and weather-strip windows or doors	12,613	3.27	109.68	0.03
Have central heating and cooling system serviced	11,408	11.88	128.18	0.13
Attic Insulation	4,775	2.60	116.45	0.06
Adjust water heater temperature to 120°F	3,415	0.39	113.84	0.01
Replace air filters	2,112	0.66	51.51	0.02
Total	139,191	25.59	280.06	0.05

Carryover Savings Calculation

The Evaluation Team calculated carryover CFL and LED savings for bulbs placed in storage in PY5, PY6 and PY7, with expected installation in PY8. For bulbs placed in storage in PY5 and PY6 the Evaluation Team applied assumptions from the 2014 UMP.⁹ For bulbs placed in storage in PY7, the Evaluation Team applied assumptions from the updated 2017 UMP.¹⁰ Going forward, the Evaluation Team will use the revised assumptions from the updated UMP to calculate carryover savings for bulbs distributed on or after PY7. Both approaches are detailed below.

Carryover Calculation Method for Bulbs Distributed in PY5 and PY6

The 2014 UMP indicates that most bulbs placed in storage (up to 97%) become installed within four years of purchase (including the initial program year) and recommends calculating the ISR when stored bulbs are installed as follows:

ISR for Bulbs in Storage

$$ISR_{Year\ 1} = ISR_{Surveyed}$$

$$ISR_{Year\ 2} = (Storage\ \%_{Year\ 1} * 41\%) + ISR_{Surveyed}$$

$$ISR_{Year\ 3} = (Storage\ \%_{Year\ 1} * 69\%) + ISR_{Surveyed}$$

$$ISR_{Year\ 4} = 97\% - ISR_{Year\ 3}$$

⁹ Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 21: Residential Lighting Evaluation Protocol. Section 4.12 In-Service Rate. December 2014.

¹⁰ Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 6: Residential Lighting Evaluation Protocol. Section 4.10 In-Service Rate. December 2017.

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Where:

ISR_{surveyed}	=	ISR from self-reported survey results for the year the measure was distributed (initial program year)
$ISR_{\text{Year 2}}$	=	Percentage of stored bulbs installed in Year 2 (one year after program participation)
$ISR_{\text{Year 3}}$	=	Percentage of stored bulbs installed in Year 3 (two years after program participation)
$ISR_{\text{Year 4}}$	=	Percentage of stored bulbs installed in Year 4 (three years after program participation)
$\text{Storage}_{\% \text{Year 1}}$	=	Percentage of bulbs placed in storage for the year the measure was distributed
41%	=	Total percentage of bulbs installed (of original bulbs placed in storage) within two years, including the program year
69%	=	Total percentage of bulbs installed (of original bulbs placed in storage) within three years, including the program year
97%	=	Total assumed percentage of bulbs installed (of original bulbs placed in storage) within four years, including the program year

The 2014 UMP assumes that 41% of all bulbs placed in storage are installed in the next year, 28% of the remaining stored bulbs are installed the following year and up to 97% of all stored bulbs will be installed by the end of the fourth year (including initial program year in which bulbs were distributed).

Carryover Calculation Method for Bulbs Distributed in PY7

The 2017 UMP's revised approach is attributed to a 2017 Massachusetts panel study which found that 24% of the LEDs that went into storage in year 1 were installed in year two. Although the study is expected to have a three-year ISR available in early 2018, only two years of data were available at the time of the UMP's 2017 update. Therefore, to estimate the lifetime ISR, the UMP directs evaluators to assume customers continue to install LEDs in storage at a rate of 24% of stored bulbs each year and recommends calculating the percentage of bulbs in storage that are installed each year as follows:

Equation 5. ISR for Bulbs in Storage

$$ISR_{\text{Year 1}} = ISR_{\text{surveyed}}$$

$$ISR_{\text{Year 2}} = (100\% - ISR_{\text{surveyed}}) * 24\%$$

$$ISR_{\text{Year 3}} = ((100\% - (ISR_{\text{surveyed}} + ISR_{\text{Year 2}})) * 24\%$$

$$ISR_{\text{Year 4}} = (100\% - (ISR_{\text{surveyed}} + ISR_{\text{Year 3}})) * 24\%$$

Where:

ISR_{surveyed}	=	ISR from self-reported survey results for the year the measure was distributed (initial program year)
$ISR_{\text{Year 2}}$	=	Percentage of stored bulbs installed in Year 2 (one year after program participation)

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ISR _{Year 3}	=	Percentage of stored bulbs installed in Year 3 (two years after program participation)
ISR _{Year 4}	=	Percentage of stored bulbs installed in Year 4 (three years after program participation)

Results

Participants placed in storage approximately 28% of PY5 CFLs, 33% of PY6 CFLs, 21% of PY6 LEDs, 33% of PY7 CFLs, and 21% of PY7 LEDs received through the program. Table 95 summarizes the percent of stored bulbs expected to be installed in the three years following the initial program year.

Table 95. HEC Percentage of Stored Bulbs Installed by Year

Distribution Year	Bulb Type	% Stored Bulbs Installed in PY7	% Stored Bulbs Installed in PY8	% Stored Bulbs Installed in PY9	% Stored Bulbs Installed in PY10
PY5	CFL	28%	6%	N/A	N/A
PY6	CFL	41%	28%	7%	N/A
PY6	LED	41%	28%	4%	N/A
PY7	CFL	N/A	24%	24%	24%
PY7	LED	N/A	24%	24%	24%

To calculate the carryover CFL and LED savings, the Evaluation Team used self-reported ISRs and applied the equations above to estimate the number of stored CFLs and LEDs distributed in from PY5 to PY7 but installed in PY8. Table 8 summarizes the number of stored CFLs and LEDs installed in PY8. The evaluation includes savings for a total of 1,749 CFLs and 530 LEDs.

Table 8. HEC Quantity of CFLs and LEDs Installed in PY7

Distribution Year	Measure	% Stored Bulbs Installed in PY8	Total Volume in Storage*	Volume Installed in PY8
PY5	13W CFL	6%	3,790	215
PY6	13W CFL	28%	3,865	1,082
PY6	9W LED	28%	388	109
PY7	13W CFL	24%	1,882	452
PY7	LED **	24%	1,754	421
Total			11,679	2,279

*Total volume in storage as of first year of distribution

**Various wattages from 5-LED and 4-CFL 1-LED Kit

Table 96 summarizes the additional carryover gross savings from the stored CFL and LED measures installed in PY8, applying recommended deemed savings values for the year in which the bulbs were installed (PY8).

Table 96. HEC Carryover Gross Savings (Savings Added to PY8)

Distribution Year	Measure	Volume Installed in PY8	Ex-Post per-bulb Savings		Total Gross Carryover Savings	
			KWH	KW	KWH	KW
PY5	13W CFL	215	32.85	0.003	7,071	0.65
PY6	13W CFL	1,082	32.85	0.003	35,547	3.25

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Distribution Year	Measure	Volume Installed in PY8	Ex-Post per-bulb Savings		Total Gross Carryover Savings	
			KWH	KW	KWH	KW
PY6	9W LED	109	37.23	0.003	4,048	0.37
PY7	13W CFL	452	32.85	0.003	14,840	1.36
PY7	LED *	421	43.36	0.004	18,251	1.67
Total		2,279	N/A	N/A	79,757	7.28

Table 97 summarizes the additional carryover net savings from the CFL and LED measures installed in PY8, applying the same NTGRs from the initial distribution year.

Table 97. HEC Carryover Net Savings (Savings Added to PY8)

Distribution Year	Measure	Total Volume Installed in PY8	Total Gross Carryover Savings		NTG		Total Net Carryover KWH Savings	
			KWH	KW	KWH	KW	KWH	KW
PY5	13W CFL	215	7,071	0.65	0.68	0.78	4,808	0.50
PY6	13W CFL	1,082	35,547	3.25	0.79	0.74	28,082	2.40
PY6	9W LED	109	4,048	0.37	0.79	0.74	3,198	0.27
PY7	13W CFL	452	14,840	1.36	0.79	0.74	11,724	1.00
PY7	LED *	421	18,251	1.67	0.79	0.74	14,418	1.23
Total		2,279	79,757	7.28	N/A	N/A	62,230	5.42

Appendix E. Neighborhood Energy Efficiency Program Mobile Home Savings Calculation Methods

Savings Methodology

The Evaluation Team applied the following steps to determine the total ex-post gross and average per-mobile home savings for the PY8 NEEP program:

Step 1: Calculated Deemed Per-Measure Savings Values: The Evaluation Team calculated per-measure savings values by applying HVAC weights using a combination of the PY8 program-tracking data and the 2009 Residential Energy Consumption Survey (RECS) data for South Carolina. The percentage of mobile home participants with cooling and electric heating come directly from the PY8 program-tracking data. However, the database does not differentiate between heat pumps and electric resistance heating for those with electric heating, and therefore the Evaluation Team relied on RECS data to parse the two heating equipment types. Table 98 outlines the applied HVAC weights while Table 99 summarizes the per-measure savings as a result of applying the HVAC weights.

Table 98. NEEP Mobile Home HVAC Weights

HVAC Type	HVAC Weight	Source/Notes
Cooling Present*	97%	PY8 NEEP Mobile Home program-tracking database**
Electric Heating	91%	PY8 NEEP Mobile Home program-tracking database***
Heat Pump	42%	Applied RECS 2009 data assumption that 46% of the 91% of participants with electric heating have heat pumps
Electric Resistance Heating	39%	Applied RECS 2009 data assumption that 43% of the 91% of participants with electric heating have electric resistance heating

* Includes cooling for participants with either central air conditioners or heat pumps.

**Participants receiving duct sealing measures were confirmed with having central cooling.

*** Utility Group E or EU provided in the PY8 NEEP program-tracking database represent participants with electric heating.

Table 99. NEEP Mobile Home Per-Measure Savings Values (with Applied HVAC Weights)

Measure	Units	KWH/Unit	KW/Unit
Digital Switch Plate Wall Thermometer	Per participant	18.35	0.000
Duct Sealing with > 10% Reduction	Per participant	609.35	0.219
Air Sealing > 30% Leakage Reduction	Per square foot	303.53	0.075
Air Sealing > 40% Leakage Reduction	Per square foot	404.70	0.100
Attic Plug & Fill Insulation (R-30)	Per square foot	1.70	0.000
Programmable Communicating Thermostat	Per participant	666.80	0.000
Reflective Roof Coating	Per participant	1.15	0.000
Belly Board Repair	Per participant	1.59	0.000
WiFi Enabled Thermostat	Per participant	666.80	0.000
CO Monitor*	Per participant	N/A	N/A

*Measure does not yield savings, distributed through the program to ensure safety.

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Step 2: Calculated an Average Per-Mobile Home Savings Value: The Evaluation Team calculated an average per-mobile home savings value by multiplying the deemed per-measure savings values from Table 99 by their respective measure quantities provided in the PY8 database and dividing by the total number of participating mobile homes (n=100). Table 100 summarizes these steps and shows the resulting average ex-post per-mobile home savings values of 1,880 KWH and 0.492 KW.

Step 3: Calculated Total Ex-Post Gross Savings: The Evaluation Team multiplied the average per-mobile home savings values of 1,880 KWH and 0.492 KW by the number of participating mobile homes (n=100) to determine the total PY8 ex-post gross savings. The mobile home component of the NEEP program achieved total ex-post gross savings of 188 MWH and 0.049 MW, with RRs of 110% and 105% for energy and demand, respectively (Table 100).

Savings Summary

Table 100 summarizes the average per-mobile home savings and total ex-post gross savings for each measure offered through the NEEP Mobile Home component.

Table 100. NEEP Mobile Home PY8 Ex-Post Savings Summary

Measure	Total Measures Installed in PY8 [A]	Units	Ex-Post per Measure		Total Ex-Post Savings	
			KWH [B]	KW [C]	KWH [A*B]	KW [A*C]
Digital Switch Plate Wall Thermometer	100	Per participant	18.35	0.000	1,835	0.00
Duct Sealing with > 10% Reduction	97	Per participant	609.35	0.219	59,107	21.25
Air Sealing > 30% Leakage Reduction	50	Per square foot	303.53	0.075	15,176	3.74
Air Sealing > 40% Leakage Reduction	50	Per square foot	404.70	0.100	20,235	4.98
Attic Plug & Fill Insulation (R-30)	43,185	Per square foot	1.70	0.000	73,323	17.58
Programmable Communicating Thermostat	9	Per participant	666.80	0.000	6,001	0.00
Reflective Roof Coating	9,045	Per participant	1.15	0.000	10,402	1.50
Belly Board Repair	354	Per participant	1.59	0.000	563	0.13
WiFi Enabled Thermostat	2	Per participant	666.80	0.000	1,334	0.00
CO Monitor	5	Per participant	N/A	N/A	N/A	N/A
Total	52,897	N/A	N/A	N/A	187,975	49.19
Average Savings per Mobile Home*					1,880	0.492

*The Average Savings per Mobile Home = Total Ex-Post Savings / Number of Participating Mobile Homes (n=100)

Differences in Ex-Ante and Ex-Post Per-Mobile Home Savings

The ex-post per-mobile home savings values for energy and demand are 10% and 5% larger, respectively, than the ex-ante per-mobile home savings values. Ex-ante applied the PY7 ex-post per-mobile home savings values

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to calculate the total PY8 ex-ante mobile home savings. Ex-ante and ex-post mobile home savings differ for the following reasons:

- **Differences in Installed Measure Quantity and Program Participation:** Both the PY7 and PY8 ex-post per-home savings values were calculated based on the unique blend of measures, installed measure quantities and participation in each respective program year. However, on average, the total number of installed measure quantities in PY8 increased by 39% (Table 101) and participation increased by 25% compared to PY7.¹¹ Had participation increased by the same percentage as installed measures, the Evaluation Team would expect similar results to PY7.

Table 101. NEEP Mobile PY6 and PY7 Installed Quantity Comparison (by Measure Type)

Measure Description	Units	Installed Measure Quantity		Δ Qty	% Difference
		PY7	PY8		
Digital Switch Plate Wall Thermometer	Thermometers	80	100	+20	25% Increase
Air Sealing > 30% Leakage Reduction	Square Feet	46	50	+4	9% Increase
Air Sealing > 40% Leakage Reduction	Square Feet	34	50	+16	47% Increase
Duct Sealing with > 10% Reduction	Participants	79	97	+18	23% Increase
Attic Plug & Fill Insulation (R-30)	Participants	29,922	43,185	+13,263	44% Increase
Belly Board Repair	Participants	795	354	-441	55% Decrease
Programmable Communicating Thermostat	Thermostat	8	9	+1	13% Increase
Reflective Roof Coating	Participants	7,004	9,045	+2,041	29% Increase
WiFi Enable Thermostat	Thermostat	0	2	+2	N/A
CO Monitor	Monitors	2	5	+3	150% Increase
Total		37,970	52,897	+ 14,927	39% Increase

- **Assumed Heating Fuel and Equipment Types:** Similar to PY7, the Evaluation Team relied on the program-tracking data to inform the share of participants with cooling and electric heating. In PY8, the number of participants with central cooling was comparable to PY7 (97% in PY8 compared to 96% in PY7) but the number of participants with electric heating increased from 83% in PY7 to 91% in PY8. As a result of the higher percentage of participants with electric heating, the ex-post per-mobile home savings increased.

¹¹ The NEEP Mobile Home component included 37,970 measures installed in 80 mobile homes in PY7 and 52,897 measures installed in 100 mobile homes in PY8.

Appendix F. Appliance Recycling Program Detailed Methods

From an evaluation perspective, appliance recycling programs differ from most DSM programs in that savings are generated by incentivizing the removal of an operable but inefficient measure, rather than rebating the installation of an efficient one. This poses unique evaluation challenges that require less-traditional methodological approaches. The methodology used in this evaluation represents the accepted industry standard for evaluating appliance recycling programs and thus provides DESC with a reliable estimate of the program's energy savings.

The Evaluation Team established ex-post gross and net savings by applying the following evaluation steps:

- **Step 1: Perform a program-tracking database review.** Reviewed contents of the program-tracking database to identify the quantity and type of recycled appliances.
- **Step 2: Verify appliance volume by applying verification rates.** Applied a 100% verification rate established through PY5 evaluation results where a representative sample of participants confirmed that 100% of the appliances were indeed recycled through the program.
- **Step 3: Review program-tracking database for appliance characteristics.** Reviewed appliance characteristic data, including age, size, appliance type (i.e., side-by-side, top freezer, chest, etc.), location and usage type (primary or secondary). Where data were missing (e.g., location), the Evaluation Team applied probable values based on assumptions from other available sources.¹²
- **Step 4: Apply ex-post per-measure savings algorithms.** Applied algorithms from the most recent version of the UMP¹³ to arrive at the average ex-post per-measure savings for recycled refrigerators and freezers.
- **Step 5: Apply a part-use factor (PUF).** Applied a PUF (established through PY5 evaluation results) that adjusts ex-post per-measure savings based on the number of months the recycled appliance was operating in the past 12 months prior to being recycled.
- **Step 6: Calculate total ex-post gross energy and demand savings per appliance type.** Summarized total reported ex-ante and ex-post energy and demand savings and calculated a program RR.
- **Step 7: Apply NTGRs.** Applied NTGRs from PY5 evaluation results to establish ex-post net energy and demand savings.

Step 1: Perform a Program-Tracking Database Desk Review

The Evaluation Team performed a thorough review of the PY8 program-tracking database and found no duplicative records or tracking errors. As a result, no adjustments to ex-ante measure quantities were needed.

¹² The PY8 database did not capture the location of the appliance when it was operating. As a result, the Evaluation Team applied location data from PY5. This methodology is consistent with the two previous program evaluations, as location data was also missing in PY7 and PY6.

¹³ Source: The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures. Chapter 7: Refrigerator Recycling Evaluation Protocol. <https://www.nrel.gov/docs/fy17osti/68563.pdf>

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Step 2: Verify Appliance Volume by Applying Verification Rates

The Evaluation Team applied a 100% verification rate established through the PY5 evaluation results to determine the verified measure quantity.

Step 3: Review Program-Tracking Database for Appliance Characteristics

The Evaluation Team reviewed the program-tracking database to determine whether the listed appliance characteristics were within a reasonable range and met program requirements. This step is important since energy savings algorithms are dependent on specific appliance characteristics, including age, size, appliance type, location and usage type (primary or secondary). The Evaluation Team reviewed the appliance characteristics described below.

Size

The Evaluation Team reviewed program-tracking data to ensure that all appliances met program size requirements (i.e., between 10 and 30 cubic feet). The Evaluation Team did not adjust records for sizing as all recycled appliances met program guidelines.

Appliance Age

Appliance age has an impact on savings as older appliances result in more energy savings compared to newer models due to the progressive increase in appliance efficiency mandated by federal standards.

The program-tracking database revealed that the majority of appliances were more than 15 years old.¹⁴ The Evaluation Team capped the age at 50 years to any records older than 50, impacting <1% of refrigerators and 1.1% of freezers.¹⁵ Table 102 shows the distribution of appliance age collected in PY8.

Table 102. ARP Refrigerator and Freezer Age Distribution

Refrigerator			Freezer		
Age (years)	%	N	Age (years)	%	N
< 5	2.3%	64	< 5	1.7%	11
5 to 9	8.3%	233	5 to 9	7.7%	49
10 to 14	29.6%	833	10 to 14	25.2%	160
15 to 19	19.6%	551	15 to 19	13.3%	84
20 to 29	23.0%	645	20 to 29	23.7%	150
30 to 39	12.5%	350	30 to 39	19.9%	126
40 to 50	4.2%	119	40 to 50	7.4%	47
> 50	0.5%	15	> 50	1.1%	7
Total		2,810	Total		634

¹⁴ Approximately 60% of recycled refrigerators and 65% of recycled freezers were 15 years old or older.

¹⁵ Adjusted age for 15 refrigerators and 7 freezers that were older than 50 years.

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Conditioned vs. Unconditioned Space

An appliance that operates in unconditioned space tends to use more energy during warm/hot periods and less energy during cooler periods. Thus, understanding the appliance's location has implications on energy and demand savings. The Evaluation Team assumed that primary appliances operate in a conditioned space. Secondary appliances have the potential to operate in unconditioned space. However, the PY8 program-tracking database did not include the location of the appliance when it was operating, nor did the PY6 or PY7 databases. Therefore, the Evaluation Team applied assumptions based on PY5 program-tracking data that 62% of refrigerators and 76% of freezers operate in unconditioned areas.

Step 4: Apply Ex-Post Per-Measure Savings Algorithms

The Evaluation Team calculated ex-post gross savings for recycled refrigerators and freezers using the UMP. The UMP provides protocols intended to improve consistency across energy-savings calculations for common program measures. The Evaluation Team chose to implement the UMP for the following reasons:

- Low-cost savings method to implement transparent EM&V practices;
- Ability to easily compare savings results from similar programs across different jurisdictions;
- Includes various methods to estimate energy savings based on data limitations; and
- Provides algorithms and default variables that are otherwise unknown.

Refrigerator Savings Algorithm

Energy savings for this program is defined as the amount of energy consumption removed from the grid. Per the UMP, the Evaluation Team used a multivariate regression model to calculate the average unit energy consumption (UEC) for recycled refrigerators, adjusted it for partial use, and multiplied it by the ex-post measure quantity. Equation 6 shows the algorithms for calculating both per-measure and total gross ex-post energy savings for recycled refrigerators.

Equation 6. ARP Energy Savings Algorithm for Recycled Refrigerators and Freezers

$$Total\ KWH\ Savings_{Ref} = Average\ Per-Measure\ KWH\ Savings_{Ref} * Qty_{Ref}$$

$$Average\ Per-Measure\ KWH\ Savings_{Ref} = Average\ UEC_{Ref} * PUF_{Ref}$$

Where:

$$UEC_{Ref} = 365.25 * [Intercept + (C_{age} * Age) + (C_{Before1990} * F_{Before1990}) + (C_{size} * Size) + (C_{SingleDoor} * F_{SingleDoor}) + (C_{SidebySide} * F_{SidebySide}) + (C_{Primary} * F_{Primary}) + (C_{Uncond,CDD} * CDD * F_{Uncond}) + (C_{Uncond,HDD} * HDD * F_{Uncond})]$$

Where:

- UEC = energy consumption of refrigerators
- PUF = factor used to adjust for the amount of time refrigerators are plugged in annually; PUF for refrigerators is 0.94 based on PY5 evaluation results (see Step 5)
- Intercept = intercept from regression model from UMP
- Coefficient (C) = The coefficient from regression model for each independent variable (see Table 103)

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- Factor (F) = The factor from actual data in the database for each independent variable (see Table 103)
- Age = actual age (or adjusted age for refrigerators >50 years old) of recycled refrigerator
- Size = actual size of the recycled refrigerator (in cubic feet)
- CDD = average daily value of 6.27 using data from ASHRAE 2016 Fundamentals for Charleston and Columbia, South Carolina
- HDD = average daily value of 5.85 using data from ASHRAE 2016 Fundamentals for Charleston and Columbia, South Carolina

Table 103 provides the algorithm coefficients and factors used to calculate ex-post gross savings.

Table 103. ARP Refrigerator UEC Regression Model Estimates and Average Program Value

Independent Variable	Coefficient (Cvariable)	Average Program Value (Fvariable)
Intercept	0.58	N/A
Age (years)	0.03	17.97
Manufactured Pre-1990	1.06	0.18
Size (cubic feet)	0.07	19.29
Single Door	-1.98	0.02
Side-by-Side	1.07	0.34
Primary Appliance	0.61	0.53
CDD	0.02	6.27
Unconditioned Space		0.62
HDD	-0.05	5.85
Unconditioned Space		0.62

Source: Uniform Methods Project: Chapter 7: Refrigerator Recycling Evaluation Protocol
<https://www.nrel.gov/docs/fy17osti/68563.pdf>

The UMP does not include protocols for calculating demand savings. Thus, the Evaluation Team applied the demand savings algorithm from the Illinois and Indiana TRMs, shown in Equation 7.

Equation 7. Demand Savings Algorithm for Recycled Refrigerators

$$KW Savings_{Ref} = \frac{Average\ Per-Measure\ KWH\ Savings_{Ref}}{8,766} * CF$$

Where:

- Coincidence Factor (CF) = a number between 0 and 1 indicating how many refrigerators are expected to be in use during the peak summer demand period; the Evaluation Team applied a CF of 1 for refrigerators (Sources: Indiana and Illinois TRMs)

Freezer Savings Algorithm

Freezer savings uses the same algorithm as refrigerator savings but different coefficient values. Table 104 provides the algorithm coefficients and factors used to calculate ex-post gross savings.

Table 104. ARP Freezer UEC Regression Model Estimates and Average Program Value

Independent Variable	Coefficient (Cvariable)	Average Program Value (Fvariable)
Intercept	-0.96	N/A
Age (years)	0.05	20.59
Manufactured Pre-1990	0.54	0.29
Size (cubic feet)	0.12	15.88
Chest Freezer	0.30	0.48
CDD	0.08	6.27
Unconditioned Space		0.76
HDD	-0.03	5.85
Unconditioned Space		0.76

Source: Uniform Methods Project: Chapter 7: Refrigerator Recycling Evaluation Protocol
<https://www.nrel.gov/docs/fy17osti/68563.pdf>

Step 5: Apply a PUF

Recycled appliances may not have operated in residential homes continuously, where some participants stored appliances unplugged. To account for this, the Evaluation Team applied PUF assumptions calculated as part of the PY5 evaluation (see Table 105).

Table 105. ARP PUF by Appliance Type

# of Weeks Appliance Operated in Past 12 Months	Annual Percentage based on # of Weeks	Percentage Refrigerators (n=68)	Percentage Freezers (n=67)	Refrigerator PUF	Freezer PUF
All the time - primary	100%	51%	38%	0.51	0.38
All the time - secondary	100%	42%	41%	0.42	0.41
36 weeks	69%	0%	2%	0.00	0.01
26 weeks	50%	1%	2%	0.01	0.01
24 weeks	46%	1%	2%	0.01	0.01
20 weeks	38%	0%	3%	0.00	0.01
12 weeks	23%	1%	0%	0.00	0.00
10 weeks	19%	0%	3%	0.00	0.01
9 weeks	17%	0%	2%	0.00	0.00
Not at all	0%	3%	9%	0.00	0.00
Part Use Adjustment Factor				0.94	0.83

Note: Values rounded for reporting purposes; valid responses only.

Source: PY5 evaluation results

Step 6: Calculate Total Ex-Post Gross Energy and Demand Savings per Appliance Type

Ex-ante savings for refrigerators and freezers are based on the PY7 evaluation results. Following Steps 2–5 above, the Evaluation Team calculated slightly higher per measure ex-post gross savings for both refrigerators and freezers. Differences in ex-ante and ex-post gross savings are driven by the variation in appliance characteristics in PY7 and PY8 including appliance age, size (i.e., cubic feet), type (i.e., single door, side-by-side, chest), and usage type (i.e., primary or secondary appliance).

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Table 106. ARP Ex-Ante and Ex-Post per Measure Savings

Measure	Ex-Ante	Ex-Post	Difference
KWH Savings			
Refrigerator	1,028	1,069	+ 4%
Freezer	680	739	+ 9%
KW Savings			
Refrigerator	0.117	0.122	+ 4%
Freezer	0.078	0.084	+ 8%

Step 7: Calculate and Apply NTGRs

The Evaluation Team applied the measure-specific NTGRs established in PY5 to the ex-post gross savings to estimate net savings for PY8.

Appendix G. EnergyWise for Your Business Detailed Methods

Sample Design

The tables below provide the sample project stratum for the Prescriptive Lighting, Custom, and Other Prescriptive Non-Lighting samples. The samples for Prescriptive New Construction Lighting and Unitary HVAC were simple random samples and therefore do not have strata boundaries or any weighting of the sample. All samples were based off the September closeout file.

Table 107. EWfYB Prescriptive Lighting Sample Stratum and Sampling Parameters

Stratum	Strata Boundary (KWH)	Population (N)*	Sample (n)	Sample Means (KWH)	Stratum Weight	Expansion Weight	Relative Weight
1	0-25,000	262	2	9,099	0.49	131.00	13.10
2	25,001-100,000	196	2	53,902	0.37	98.00	9.80
3	100,001-1,500,000	73	6	307,913	0.14	12.17	1.22
Total		531	10				

*Total number of projects does not match final reported total because sampling occurred on the September partial dataset.

Table 108. EWfYB Custom Sample Stratum and Sampling Parameters

Stratum	Strata Boundary (KWH)	Population (N)*	Sample (n)	Sample Means (KWH)	Stratum Weight	Expansion Weight	Relative Weight
1	0-80,000	8	5	35,219	0.53	1.56	0.16
2	80,001-150,000	4	2	104,458	0.27	2.13	0.21
3	150,001-800,000	3	3	511,357	0.20	1.00	0.10
Total		15	10				

*Total number of projects does not match final reported total because sampling occurred on the September partial dataset.

Table 109. EWfYB Other Prescriptive Non-Lighting Sample Stratum and Sampling Parameters

Stratum	Strata Boundary (KWH)	Population (N)*	Sample (n)	Sample Means (KWH)	Stratum Weight	Expansion Weight	Relative Weight
1	0-10,000	14	2	5,469	0.70	7.55	1.51
2	10,001-50,000	5	2	23,956	0.25	2.33	0.47
3	50,001-500,000	1	1	264,505	0.05	1.00	0.20
Total		20	5				

*Total number of projects does not match final reported total because sampling occurred on the September partial dataset.

Realization Rate Summary

The following charts provide a visual comparison between ex-ante and ex-post savings across the various samples. The line in the graph represents a 100% RR (or 100% correlation). Generally, the energy savings correlate well between ex-ante and ex-post savings.

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Figure 1. EWfYB Ex-Ante vs. Ex-Post – Combined KWH

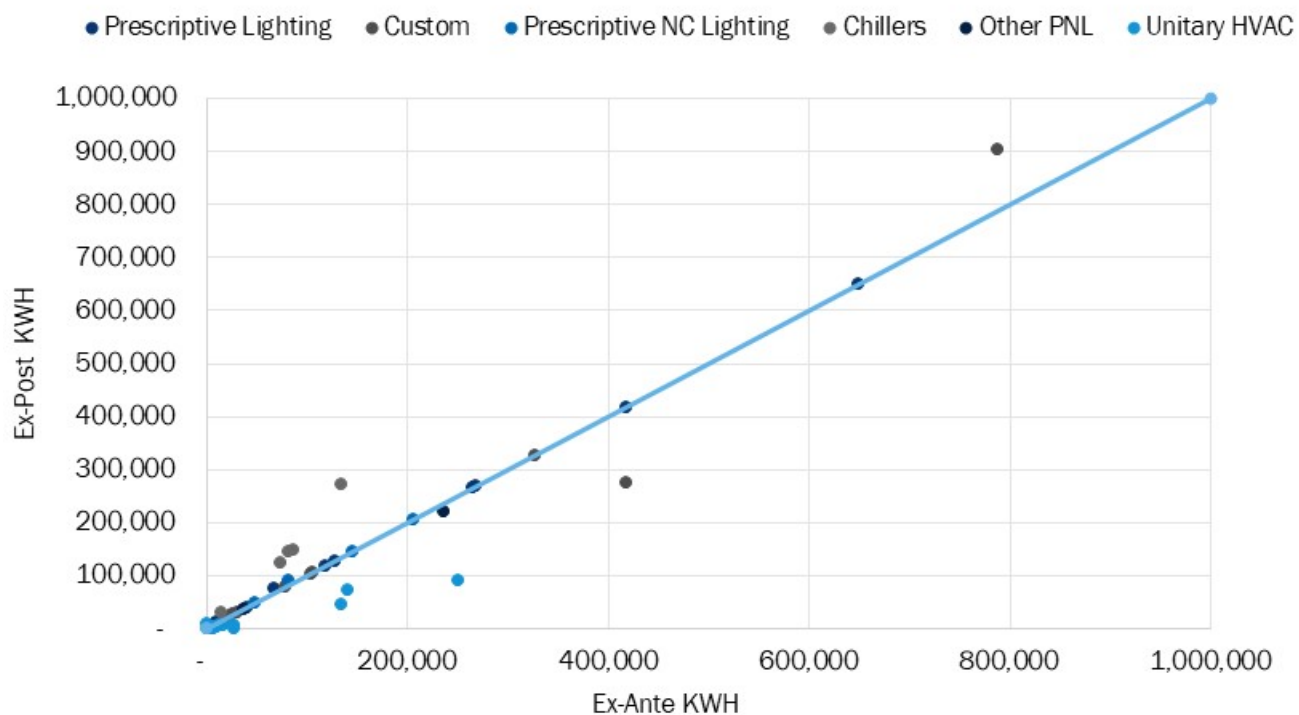
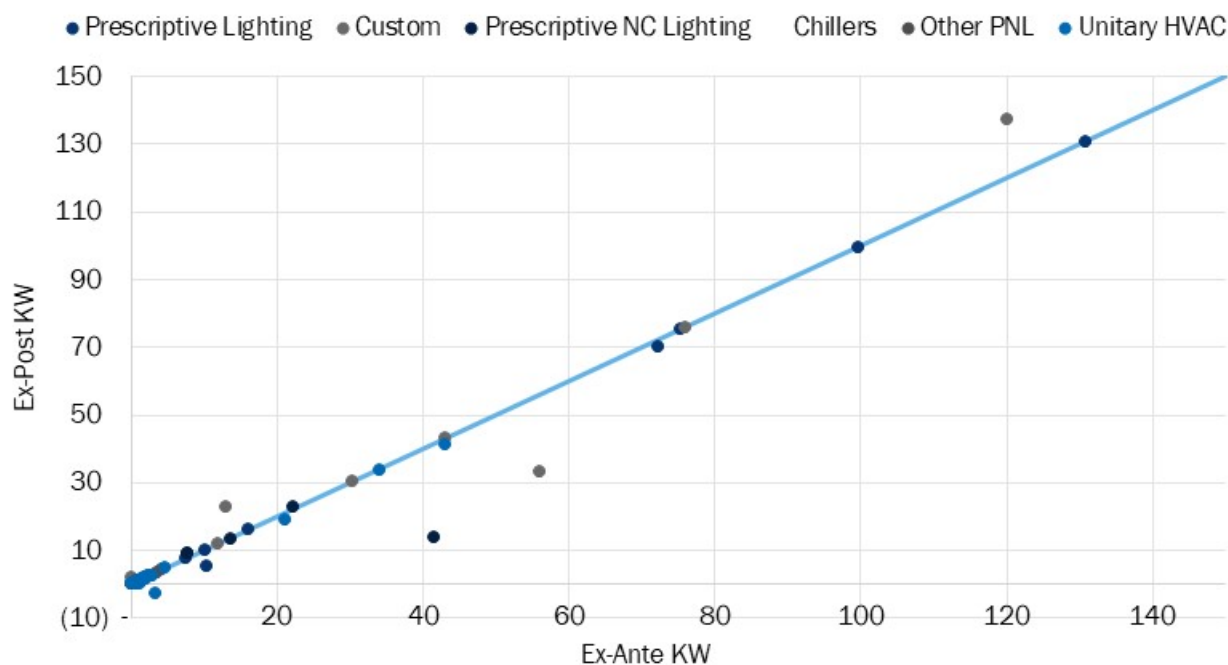


Figure 2. EWfYB Ex-Ante vs. Ex-Post – Combined KW



Desk Review Details by Application Type

Prescriptive Lighting and New Construction Lighting

The Evaluation Team performed desk reviews on a sample of 10 out of the 660 Prescriptive Lighting projects and 5 out of the 20 Prescriptive New Construction Lighting projects. To determine ex-post gross savings, the Evaluation Team adjusted several parameters within the lighting calculations, including:

- **Coincidence factors:** Ex-ante calculations began aligning the coincidence factors with the CEAM based on building type for some projects, but still relied on a generalized coincidence factor of 0.747 for other projects. In instances where a generalized coincidence factor was used, the Evaluation Team adjusted the coincidence factor to align with the building type (e.g., office, warehouse, exterior) based on the CEAM. This resulted in either increasing or decreasing the assumed factor, depending on the specific project. For all exterior LED lighting measures, the team applied a coincidence factor of 0.28, based on PY4 evaluation efforts.
- **Exterior Lighting Space Type:** For five exterior lighting measures, discrepancies between ex-ante and ex-post building type identification were observed. These measures were improperly specified as interior lighting using project-level information, resulting in the incorrect application of waste heat and coincidence factors for interior lighting. The Evaluation Team adjusted the space types at the individual measure level resulting in an average increase of 6% and decrease of 49% in energy and demand savings, respectively, for the five measures.

Table 110 and Table 111 list projects and their individual RRs in order of largest to smallest ex-post energy savings within similar reasons for differences.

Table 110. EWfYB Prescriptive Lighting Project Realization Rates

Project	Ex-Post KWH	Ex-Post KW	Energy RR	Demand RR	Reasons for Differences
1	268,184	70.2	100%	97%	Ex-post determines "building type" at the individual measure level accounting for variation in lighting applications within projects. Ex-ante uses "building type" across all measures, occasionally applying incorrect waste heat factors or coincidence factors to measure applications; in particular, exterior lighting measures using interior parameters.
2	76,576	5.2	112%	50%	
3	10,912	0.8	112%	100%	
4	649,086	130.8	100%	100%	No discrepancies
5	417,464	99.7	100%	100%	
6	265,739	75.4	100%	100%	
7	128,148	16.2	100%	100%	
8	118,808	7.6	100%	100%	
9	39,652	10.3	100%	100%	
10	8,486	1.8	100%	100%	

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Table 111. EWFYB Prescriptive New Construction Lighting Project Realization Rates

Project	Ex-Post KWH	Ex-Post KW	Energy RR	Demand RR	Reasons for Differences
1	206,639	13.9	100%	33%	Ex-ante applies coincidence factor of 0.747 to all lights. Ex-post uses coincidence factor from CEAM based on building type and whether the lights are interior/exterior.
2	145,909	13.6	100%	99%	
3	47,693	9.3	100%	120%	
4	5,007	23.0	100%	103%	
5	89,850	9.3	110%	119%	Ex-ante applies waste heat factors based on a heating and cooling type of No A/C/ Unknown. Ex-post applies waste heat factor values for that of A/C/ Unknown based on the confirmation that the facility has AC present.

Custom Projects

The Evaluation Team performed desk reviews on a sample of 10 out of the 21 Custom projects, with the sample consisting of five HVAC projects, two refrigeration projects, one air compressor system project, one building commissioning project, and one lighting controls project. Table 112 lists projects in order of largest to smallest ex-post energy savings within similar reasons for differences. More detail on the reasons for differences by Custom project type is provided below the table.

Table 112. EWFYB Custom Projects Realization Rates

#	Project Type	Ex-Post KWH	Ex-Post KW	Energy RR	Demand RR	Reasons for Differences
1	Refrigeration	903,003	137.4	115%	115%	Ex-post calculation updated efficiency and affinity law calculation.
2	Air compressor system upgrade	276,236	33.3	66%	59%	Ex-post savings based on calculations using algorithms from the IL and NYS TRMs.
3	HVAC	25,845	23.0	100%	177%	Inconsistency between ex-ante reported demand savings and demand savings from the model output.
4	Exterior lighting controls	19,461	2.1	101%	N/A	Ex-post uses CEAM-aligned hours of operation.
5	HVAC	326,984	76.0	100%	100%	No discrepancies
6	HVAC	105,246	43.19	100%	100%	
7	Building tune up/ commissioning	103,669	-	100%	N/A	
8	Refrigeration	79,301	12.00	100%	100%	
9	HVAC	30,106	30.37	100%	100%	
10	HVAC	21,573	-	100%	N/A	

Note: The Evaluation Team cannot calculate RRs when the ex-ante or ex-post savings are 0, and therefore denote these projects with 'N/A'.

The Evaluation Team relied on energy models from the project vendors for verifying four out of the five HVAC projects with the remaining project having retrofit metering data for calculating ex-ante savings. After reviewing all project documentation, including the model outputs where applicable, the Evaluation Team found an inconsistency between ex-ante reported demand savings and the demand savings from the model output in one project. The resulting demand RR for this project was 177%. For all HVAC projects, the Evaluation Team

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performed secondary calculations, including using CEAM methods, comparing the claimed savings per-ton with similar projects from past program years. In addition, the team requested and performed a site level billing analysis using actual facility-specific monthly consumption data for select projects. This multi-point validation approach allowed for replacement of one validation approach with another when necessary, such as when billing information was not robust enough to allow for analysis. This comparison verified that all but one (as described above) of the per-project claimed savings totals were not drastically out of line with what is expected for these types of projects.

To verify the lighting controls project savings, the Evaluation Team reviewed all project documentation to verify the lighting fixture type, control quantity, and wattages. The Evaluation Team calculated savings in accordance with the CEAM, including demand savings using an appropriate coincidence factor for the space type, whereas ex-ante did not report demand savings.

The remaining projects, including the air compressor system upgrade, refrigeration, and building commissioning, relied on the review of provided calculations and/or meter-based savings.

For the air compressor system upgrade project, the Evaluation Team determined that ex-ante claimed savings from the metering data were nearly double that of the algorithmically calculated savings.¹⁶ Since the pre and post periods of the metering data were 8.5 and 14 days, respectively, the Evaluation Team determined that the metering periods used were potentially not representative of the long-term operation characteristics of the manufacturing facility. Additionally, the Evaluation Team requested and used actual facility monthly billing data to estimate savings. However, comparing actual pre and post monthly billing data resulted in an increase in consumption following completion of the project. Ultimately, the Evaluation Team concluded that the use of actual consumption data would be inaccurate for quantifying savings for this project. Therefore, ex-post savings are the result from algorithmic calculations, resulting in RRs for energy and demand of 66% and 59%.

Additionally, for the refrigeration project involving the installation of variable frequency drives (VFDs) in a frozen food warehouse, the Evaluation Team reviewed the provided calculations and adjusted parameters for accuracy. The resulting RRs for energy and demand are both 115% due to two adjustments that the Evaluation Team made to the fan affinity calculations. The first adjustment was a change of the affinity exponent from 2.7 to 3.0, aligning with the standard value from the fan affinity law relationship. The second adjustment involved changing the assumed fan motor efficiency value from 0.985 to 0.941, aligning with the default efficiency from the NEMA Premium Motor Efficiency and Selection Guide¹⁷ for motors of this size.

For the building commissioning and other refrigeration project, no errors or inconsistencies were found in the metering data and calculations. Therefore, ex-post energy and demand savings is equal to ex-ante, yielding 100% RRs for the two projects. As a whole, the custom program achieved 99% and 103% of energy and demand, savings, respectively.

Prescriptive Chiller Projects

The Evaluation Team performed desk reviews on a sample of five out of the eight chiller projects. The team found that ex-ante full and part load baseline efficiencies for the units being replaced did not align with the CEAM-specified minimum baseline efficiencies, which the team used in ex-post calculations. Table 113 lists projects in order of largest to smallest ex-post energy savings.

¹⁶ Algorithms used: Illinois Statewide Technical Reference Manual V6.0, section 4.7; New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs. Version 5. The Evaluation Team leveraged other technical reference manuals for algorithms because these measures are not included in the current version of the CEAM.

¹⁷ Premium Efficiency Motor Selection and Application Guide. U.S Department of Energy. Table 2-6

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Table 113. EWfYB Chiller Projects Realization Rates

Project	Ex-Post KWH	Ex-Post KW	Energy RR	Demand RR	Reasons for Differences
1	273,051	37.6	203%	101%	Ex-post calculations use CEAM specified minimum baseline efficiencies.
2	148,515	13.7	170%	101%	
3	143,775	11.9	175%	101%	
4	123,652	18.2	168%	101%	
5	30,908	5.0	205%	101%	

Prescriptive Unitary HVAC Projects

The Evaluation Team performed desk reviews on a sample of 20 out of the 32 unitary HVAC projects. Table 114 lists projects in order of largest to smallest ex-post energy savings within similar reasons for differences.

Table 114. EWfYB Unitary HVAC Project Realization Rates

Project	Ex-Post KWH	Ex-Post KW	Energy RR	Demand RR	Reasons for Differences
1	194,551	47.0	77%	109%	Ex-post uses minimum baseline efficiency values aligning with federal standards as of January 1, 2018 based on size of equipment being >65 kBtuh.
2	109,145	31.2	81%	147%	
3	83,858	48.5	60%	142%	
4	15,680	3.3	57%	143%	
5	14,067	1.6	82%	109%	
6	13,868	6.5	N/A	136%	
7	7,587	5.0	52%	198%	
8	6,731	2.9	56%	103%	
9	4,141	2.2	42%	101%	
10	2,527	1.8	59%	215%	
11	1,257	1.0	33%	127%	
12	1,167	0.3	19%	23%	
13	734	1.4	17%	127%	
14	580	0.5	12%	72%	
15	(11,203)	3.5	-39%	N/A	
16	3,268	0.7	100%	49%	Ex-post uses minimum baseline efficiency values aligning with ASHRAE 90.1 2013 based on size of equipment being <65 kBtuh.
17	3,249	2.4	59%	200%	
18	1,120	0.4	71%	71%	
19	1,016	0.1	100%	21%	
20	618	(2.7)	9%	-56%	

Other Prescriptive Non-Lighting Projects

The Evaluation team grouped the remaining prescriptive non-lighting projects together to develop a sample based on the relatively small share of energy savings for these projects. Five total projects of 23 were sampled from this grouping including cooler and freezer night covers, refrigerated case lighting and controls, glass door refrigerator and freezer replacements, and antisweat heater controls. The team only found one discrepancy for the LED refrigerated case lighting and control measures. For these measures, the team determined that

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ex-ante energy savings assumed a value of 8,766 for hours of operation (24/7). Based on a review of program materials and site-specific information, the team found these facilities to not be 24-hour facilities and therefore applied hours of operation from the CEAM for the appropriate building type. Table 115 lists projects in order of largest to smallest ex-post energy savings within similar reasons for differences.

Table 115. EWFYB Other Prescriptive Non-Lighting Realization Rates

Project	Ex-Post KWH	Ex-Post KW	Energy RR	Demand RR	Reasons for Differences
1	221,882	3.5	94%	100%	Ex-post calculations use CEAM-aligned refrigerated case lighting hours of operation for that of building type.
2	4,177	0.9	54%	100%	
3	36,716	4.1	100%	100%	No discrepancies

Appendix H. Small Business Energy Solutions Detailed Methods

Desk Review Sample Design

The tables below provide the sample project stratum for the lighting and refrigeration samples. All samples were based off the partial dataset file used for sampling purposes.

Table 116. SBES Lighting Sample Stratum and Sampling Parameters

Stratum	Strata Boundary (KWH)	Population (N)*	Sample (n)	Sample Means (KWH)	Stratum Weight	Expansion Weight	Relative Weight
1	1-75,00	118	7	4,616	0.463	16.66	0.67
2	7,501-17,500	104	8	11,573	0.408	12.72	0.51
3	17,501-75,000	33	10	26,371	0.129	3.39	0.14
Total		255	25				

*Total number of projects does not match final reported total because sampling occurred on the September partial dataset.

Table 117. SBES Refrigeration Project Sample Stratum and Sampling Parameters

Stratum	Strata Boundary (KWH)	Population (N)*	Sample (n)	Sample Means (KWH)	Stratum Weight	Expansion Weight	Relative Weight
1	1-9,000	15	2	8,774	0.319	8.82	0.88
2	9,001-20,000	22	3	13,732	0.468	6.67	0.67
3	20,001-55,000	10	5	24,380	0.213	2.00	0.20
Total		47	10				

*Total number of projects does not match final reported total because sampling occurred on the September partial dataset.

Desk Review Detailed Findings

Lighting Projects

The desk review sample for lighting projects included 25 projects. These projects consisted of LED measures for both exterior and interior spaces as well as refrigerated case lighting. For each project, the Evaluation Team requested all applicable project documents such as applications, invoices, specification sheets, and other calculation files as necessary. Documentation for the projects included a project proposal that included the energy savings values, but no demand savings values, even though the program-tracking database includes demand savings for many of the sampled projects. The Evaluation Team requested additional insight or examples on how demand savings in the program-tracking database were determined, but ultimately were not provided the additional context. For ex-post savings, the Evaluation Team followed the methods and deemed inputs from the CEAM. To determine ex-post gross savings, several parameters within the lighting calculations were adjusted, including:

- **Exterior Lighting Demand Savings:** Ex-ante did not include demand savings in the database for most exterior lighting measures. The Evaluation Team calculated demand savings using project-specific demand reductions and the CEAM-specified coincidence factor for exterior lighting. Demand savings from the sampled exterior lighting measures account for nearly 10% of the sampled lighting project ex-post total.
- **Building Type:** Discrepancies between ex-ante and ex-post building type identification were observed in approximately 13% of desk-reviewed lighting measures. Ex-ante building types were assigned at

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the project level and distributed throughout the individual measures within that project. To calculate ex-post savings, the Evaluation Team reviewed the building type classification and adjusted at the measure level as appropriate. For example, some exterior lighting measures were improperly specified as interior lighting measures using project-level information, resulting in the application of incorrect waste heat factors and/or coincidence factors for exterior lighting. The Evaluation Team adjusted building types on a measure-by-measure basis.

- **Coincidence Factors and Waste Heat Factors:** The Evaluation Team applied coincidence factors and waste heat factors to align with the building type (e.g., office, warehouse, exterior) based on the CEAM. Since there are no ex-ante demand calculation methods available for review, it is unclear what coincidence factors or waste heat factors were used to estimate ex-ante savings. The Evaluation Team, therefore, cannot pinpoint specific differences between ex-ante and ex-post demand savings.

Table 118 details the 25 sampled projects and their individual RRs, along with a short description of what caused the differences in verified and tracked savings. Table 118 lists projects in order of largest to smallest verified energy savings, grouped by similar reasons for difference.

Table 118. SBES Lighting Project Realization Rates

Project	Ex-Post KWH	Ex-Post KW	KWH RR	KW RR	Reasons for Differences
1	11,208	0.86	100%	N/A	Ex-ante tracking database did not include demand savings for exterior lighting measures.
2	9,435	0.73	100%	N/A	
3	6,880	0.44	100%	N/A	
4	5,788	0.45	100%	N/A	
5	34,231	5.37	100%	141%	Ex-post applied coincidence and/or waste heat factors from the CEAM for the appropriate building type.
6	21,844	8.00	100%	125%	
7	12,547	2.94	100%	123%	
8	8,388	3.09	100%	125%	
9	3,047	1.04	103%	127%	
10	2,382	0.98	103%	125%	
11	371	0.18	100%	131%	
12	40,388	5.24	100%	175%	Ex-post applied coincidence and/or waste heat factors from the CEAM for the appropriate building type. Ex-ante program-tracking database did not include demand savings for exterior lighting measures.
13	40,035	4.09	100%	171%	
14	27,594	6.12	98%	216%	
15	22,302	7.53	98%	134%	
16	19,851	6.59	103%	131%	
17	19,805	2.72	100%	210%	
18	18,030	4.24	100%	226%	
19	16,088	3.68	100%	127%	
20	14,074	3.55	100%	120%	
21	13,060	4.80	100%	126%	
22	6,820	0.63	99%	207%	
23	7,101	0.54	100%	366%	
24	8,172	2.48	105%	124%	

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Project	Ex-Post KWH	Ex-Post KW	KWH RR	KW RR	Reasons for Differences
25	19,052	2.19	100%	102%	Ex-post applied CEAM calculation methodology, differing from that of ex-ante

Refrigeration Projects

The 10 projects selected for the refrigeration sample consist of four separate refrigeration measures: evaporative/compressor controls, walk-in cooler/freezer temperature controls, cooler/freezer door heater controls, and novelty cooler shutoff controls. To calculate ex-ante savings, the Implementation Team used detailed methodologies using actual specifications from the installed measures, as previously documented in the CEAM. The Evaluation Team reviewed ex-ante methodologies for any apparent errors or inconsistencies and made the following adjustments:

- **Novelty Cooler Shutoff Demand Savings:** The Evaluation Team calculated ex-post demand savings for these measures in accordance with the CEAM. The database did not report ex-ante demand savings for these measures. Demand savings from the sampled novelty cooler shutoff measures accounts for approximately one-third of the sampled refrigeration project ex-post total.
- **Walk-in Cooler/Freezer Temperature Control Savings:** The CEAM does not provide details on demand savings estimation methods for this measure, so the Evaluation Team reviewed the implementation team's methods for accuracy. The Evaluation Team agreed with the implementation team's method but observed that the ex-ante savings did not include a coincidence factor. Ex-post estimates therefore applied a coincidence factor of 0.75, taken from the cooler/freezer door heater controls measure. This coincidence factor was the most appropriate to use until additional research can be performed. Resulting RRs for these measures are 75%.

Table 119 details the 10 sampled projects and their individual RRs, along with a short description of what caused the differences in verified and tracked savings. Table 119 lists projects in order of largest to smallest verified energy savings.

Table 119. SBES Refrigeration Project Realization Rates

Project	Ex-Post KWH	Ex-Post KW	Energy RR	Demand RR	Reasons for Differences
1	26,039	2.02	100%	94%	Ex-post applied coincidence factor of 0.75 to demand savings for walk-in cooler/freezer temperature control measures. Rounding discrepancies in ex-ante calculations.
2	25,365	1.97	100%	94%	
3	20,384	1.41	100%	88%	
4	15,465	1.08	100%	92%	
5	13,906	0.98	100%	87%	
6	11,776	0.86	100%	92%	
7	8,593	0.54	100%	82%	
8	28,142	2.80	100%	130%	Ex-post applied coincidence factor of 0.75 to demand savings for walk-in cooler/freezer temperature control measures. Database ex-ante does not include demand savings.
9	21,864	6.44	100%	521%	
10	8,935	0.16	100%	100%	No Discrepancies

Refrigeration NTGR Methods

Gross savings are the change in energy consumption (or demand) that results directly from program-related actions taken by program participants, regardless of why they took those actions. Net savings are defined as the savings (i.e., change in consumption) that can be attributed to the program. Net savings may be lower than total program gross savings due to energy savings that would have occurred in the absence of the program (free riders). Conversely, the net savings may be higher than total program gross savings due to energy savings that occurred because of the program, but that the program did not directly incentivize (spillover). FR and spillover are represented as percentages of gross savings from the program. The NTGR is then calculated as:

$$NTGR = 1 - FR + SO$$

The preliminary assessment of the NTGR for the refrigeration measures in the SBES Program was based on self-reported information from a multi-mode phone and web-based survey with all SBES participants (census method). The survey was conducted in April of 2019. The Evaluation Team did not update the NTGR for lighting measures and used the values from the previous years, as there have not been any major changes that would have significantly altered the lighting NTGR.

Free Ridership

Free Ridership was determined based on an average of two different measures of program influence: Program Component (PC) Influence and Program Likelihood (PL) Influence. SBES participants were asked a series of questions to measure PC Influence and PL influence.

Program Component (PC) Influence

Participants were asked to rate the influence of seven program components in their decision to pursue energy efficient upgrades through the program. These questions were asked on a scale of 0 to 10, where 0 was “not influential” and 10 had “a great deal of influence”. Higher scores indicate higher program influence.

Participants rated the following components:

- The discount from DESC
- The free onsite energy analysis
- The technical assistance offered
- Information learned through program marketing and outreach
- The direct installation of measures (as opposed to having to look for a contractor)
- Their own company’s standard practices
- Previous participation in such programs

Program Likelihood (PL) Influence

The Evaluation Team assessed program influence from three perspectives. Together, these measure the overall likelihood that participants would have installed the same equipment in the absence of the program.

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- **Program Efficiency (PE) Influence.** Measures the likelihood that participants would have installed equipment that was as efficient as what was received through the program. These questions were asked on a scale of 0 to 10, where 0 was “not at all likely” and 10 had “very likely”. A lower score indicates greater program influence.
- **Program Timing (PT) Influence.** Measures when participants would have installed equipment had it not been for the program. Participants were asked to choose in what time period they would have installed efficient measures had it not been for the program. Given ranges were: within 3 months of when you did, 3 to 6 months later, 6 months to a year later, more than a year later, or never. The farther out participants report (or answers of “never”), the greater the likelihood that the program influenced them to pursue efficient equipment earlier than they would have on their own.
- **Program Quantity (PQ) Influence.** For each type of equipment received, measures how many participants would have installed without the program. The fewer measures they would have installed, the greater the influence of the program.

FR Scoring

The Evaluation Team converted all of these components into scores between 0 and 1, where 0 is “not at all a free rider” and 1 is “a complete free rider”. “Don’t know” answers were removed or made neutral for the final calculation. Scores were assigned to each answer category as follows:

Table 120. SBES Refrigeration FR Summary

FR Component	Survey Question	Score
Efficiency	How likely is it that you would have, on your own and without help from the program, upgraded to the Refrigeration measure that was just as efficient as what you received?	Score (0 to 10) / 10
Timing	If it had not been for the program, when would you have made refrigeration upgrades?	Within 1 months of when you did = 1 3 to 6 months later = 0.8 6 months to 1 year later = 0.6 More than a year later = 0.5 Never = 0 Don't Know = 1
Quantity	If you would have installed these upgrades on your own without help from the program, would you have installed the same quantity or fewer?	Score (0 to 10)/10

The following algorithm calculates FR for each participant:

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Free Ridership Algorithm

$$FR = Average(PL, PC)$$

Where:

$$PL = PE * PT * PQ$$

$$PC = 1 - Maximum(PC_a - e/10)$$

As the equation above indicates, overall program likelihood (PL) and the influence of individual program components (PC) hold equal weight, as these aspects of the program motivate participants in different ways. The Evaluation Team utilized PE as the base influence score and then, in order to ensure all aspects of program influence were captured, gave credit for timing and quantity.

After calculating individual free ridership scores a weighted average score was calculated that gives more weight to participants with more savings through the program. A separate weighted average score was calculated for KWH and for KW savings, as was done in DESC's other Business Program, Energy Wise for Your Business.

FR Results

The resulting FR score was 0.1 for KWH and 0.11 for KW. These scores suggest extremely low free ridership and high levels of program influence. Low FR (0.20 or lower¹⁸) is typical for small business programs whose customers face numerous barriers in pursuing energy efficient upgrades on their own.

Spillover

The Evaluation Team found no evidence of spillover savings amongst PY8 survey participants. As such, the refrigeration NTGR uses a spillover value of zero.

¹⁸ Recent small business direct install evaluations conducted by the Evaluation Team for Ameren in Illinois (2014) and for the Long Island Power Authority (LIPA) in New York (2011) found free ridership levels of 0.89 and 0.87, respectively.

Appendix I. Home Energy Reports Detailed Methods

In this section details the evaluation activities conducted for the PY8 HER program, along with the methods that were used. The evaluation effort focuses on estimating PY8 impacts.

The primary objective of this evaluation was to measure the energy savings impacts of the program, and to determine whether the program leads to additional participation in other energy efficiency rebate programs administered by DESC. To address this, the Evaluation Team conducted four primary evaluation tasks:

- **Program-Tracking Database Validation:** The Evaluation Team reviewed DESC's program-tracking database to verify the total number of program participants as well as customers who opted-out of the program or moved (e.g., final bills).
- **Equivalency Assessment:** The Evaluation Team assessed equivalency of treatment and comparison group customers based on baseline usage.
- **Billing Analysis:** The Evaluation Team conducted a limited dependent variable (LDV) regression analysis to estimate net program energy savings.
- **Channeling Analysis:** The Evaluation Team determined whether the HER program treatment generates lift in other energy efficiency programs and calculated a savings adjustment to determine what portion of net savings estimates is captured in other program databases.

For this evaluation, the Evaluation Team applied 41% MW impacts given that the program achieved 41% of its MWH impacts. The Evaluation Team believe this is the best approach because the team does not have insight into the interactive effects of the energy savings that affect demand.

Data Sources and Analytical Methods

The Evaluation Team used the following data sources to evaluate the HER program:

- Program-tracking databases for all DESC residential programs
- Information on key program efforts and dates gathered through program staff interviews
- Program implementer database with program customer information including demographics, program participation details, and control group designations
- Program implementer database with details about which additional DESC programs customers were recommended through their Home Energy Reports
- Electric billing usage data for treatment and comparison groups
- DESC HER program participant database for PY1 through PY8
- Sample Home Energy Reports and Home Energy Updates for PY8

Data Preparation

This section provides a summary of data cleaning for the billing analysis. The data used in the billing analysis comes from monthly billing data from December 2008 to January 2019 obtained from Direct Options.

The Evaluation Team eliminated some households in the statistical analysis to ensure adequacy of energy usage data during heating and cooling seasons. The number of households excluded from analysis represents

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approximately 2% of the total accounts available for billing analysis. To develop the dataset used for the statistical analysis, the Evaluation Team selected treatment and comparison groups based on the criteria outlined below.

Removed customers based on the following criteria:

- SCANA Net Energy Metering (NEM) customers
- Missing both the first report date and cohort designations¹⁹
- Missing start and end meter dates in billing data
- Insufficient data in pre and post period to perform the billing analysis
- Very low usage data: a daily average of less than 2 KWH of pre- or post-consumption
- Very high usage data: a daily average of more than 300 KWH of pre- or post-consumption
- Removed observations based on the following criteria:
 - Missing billing reads, duplicative, negative consumption values, missing usage data and bill duration data, zero days in a billing period, or billing periods longer than 100 days
 - Determined the average daily usage for each customer based upon their billing cycles
 - Linked energy usage with the customer-specific program start date
 - Assigned first update dates based on when the treatment group customers received their first module (reflects report date variable in module data). For comparison group customers, the Evaluation Team randomly assigned a first update date to each customer in the comparison group based on the distribution of treatment group first update dates.

Discussion of Comparison Group

In 2016, Direct Options (DO), the implementer of the HER program and Opinion Dynamics (the evaluation team) identified a comparison group in anticipation of an impact assessment (i.e., billing analysis). The comparison group was selected based on several demographic and housing attributes (such as usage, income, age, education, etc.). Using these attributes, a K-means clustering methodology was used to select 16,418 comparison group customers.

The Evaluation Team conducted an equivalency check during the PY8 analysis, in which it was determined that the treatment and comparison groups for all program cohorts were equivalent based on demographic and housing attributes. The Evaluation Team also performed a comparison of usage between the treatment and comparison groups for all of the cohorts together. The Evaluation Team examined the average daily energy consumption for the 12-month period prior to when the first updates were received for treatment and comparison group customers. Overall, the Evaluation Team found that while there was a gap between the control and treatment pre-period average daily consumption values (see Table 85), the gap was not large

¹⁹ For treatment customers, the Evaluation Team excluded customers with no first update date (from module data). For comparison group customers, the Evaluation Team excluded customers without an "is_matched_control flag" (from customer data).

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enough to determine that the groups were inequivalent. The Evaluation Team determined that the groups were sufficiently equivalent to move forward with the analysis.

Table 121. HER Pre-Program KWH Average Daily Consumption

Customers	Pre-Program Average Daily KWH Consumption Treatment	
	Treatment	Comparison
All Participants	43.0	41.6

Modeling Program Impacts

The Evaluation Team conducted a billing analysis to assess changes in energy consumption attributable to the HER program. This analysis relied upon a statistical analysis of monthly electricity billing data for all DESC customers that received a HER (the treatment group) and a matched sample of customers that did not receive a HER (the comparison group). Our analysis used an “average treatment effect on the treated” (ATT) estimate of program savings, which applies savings to the study population portion that receives a report during the program year being studied. Before running the model, the Evaluation Team pro-rated customers that joined the program after PY8 started or left before PY8 ended, so that the team only included the average daily consumption for time they spent in the program in PY8.

The Evaluation Team used a LDV analysis to estimate program effects. The results of LDV models are usually very similar to the results obtained through use of the weather adjusted linear fixed effects models, the type of model the Evaluation Team used in our PY6 evaluation. Using an LDV model allowed the team to rule out whether any difference in the savings value is due to different model specifications. LDV models run exclusively on post-period data and pre-period information is incorporated in the form of pre-period specific variables (e.g. pre-period winter season average daily consumption).

Because of the method used to select the comparison group, the treatment and comparison groups are assumed to have experienced similar events with similar effects on energy use. However, to account for possible differences in weather that may exist, the model includes the average daily consumption in the pre-period for the summer and the winter. The model representing these factors in estimating average daily consumption (ADC) and its change is:

Equation 8. Energy Savings Model

$$ADC_{it} = \alpha_i + \beta_0 Treat + \beta_1 Pre_ADC + \beta_2 pre_ADC_summ + \beta_3 pre_ADC_win + \beta_4 Month + \beta_5 Pre_ADC \cdot Month + \beta_6 pre_ADC_summ \cdot Month + \beta_7 pre_ADC_win \cdot Month + \varepsilon_{it}$$

Where:

ADC_{it} = Average daily consumption (KWH) for household i at time t

α = Overall intercept

$Treat$ = Indicator for treatment recipient

Pre_ADC = Indicator for pre-period average daily consumption

Pre_ADC_summ = Indicator for the pre-period ADC in the summer

Pre_ADC_win = Indicator for the pre-period ADC in the winter

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Month= Indicator for each month-year combination

β_{0-7} = Model coefficients

ε_{it} = Error

Finally, the Evaluation Team added a vector of month-year intercept term to help control for any differences between months that affected all participants (comparison and treatment) similarly.

Estimating Program Savings

The first step in calculating average program savings was accomplished by using the coefficients from the estimating equation (Equation 1 above) to estimate average daily consumption (ADC) under two conditions: 1) the comparison group in the treatment period, and 2) the treatment group in the treatment period. The first estimate was made by evaluating Equation 1 with the Treatment variable set to 0 (to represent the comparison group), and the Post variable set to 1 (to reflect the comparison group difference in consumption from pre- to post-periods). The second estimate was made by evaluating Equation 1 with the Treatment variable set to 1 (to represent participation), and the Post variable remaining at 1 (again to represent the post-period). The difference between those two estimates constitutes the average daily KWH savings per household.

Program savings as a percent reduction were calculated by dividing the average daily savings estimate described above by the estimate of ADC under the conditions of non-participation.²⁰ To calculate average household savings attributable to the program for the evaluated period, the average, raw, per-household daily savings was multiplied by the average number of days in the evaluated period (i.e., the average number of days between receiving the first update and the endpoint of the post-participation billing periods). The Evaluation Team estimated savings using this model for each season covered by the pre- and post-periods for all cohorts.

Channeling Analysis

The HER program promotes other DESC energy efficiency programs in program materials and directs customers to DESC resources to sign up for these additional programs.

The purpose of a channeling analysis is to answer the following questions:

- Does the program treatment have an incremental effect on participation in other DESC residential energy efficiency programs? (participation lift)
- What portion of savings from the program treatment is double counted by other DESC residential energy efficiency programs? (savings adjustment)

The savings tips provided in the reports could lead to additional program participation. If program materials were effective, the Evaluation Team would expect to see a lift in participation in other DESC residential energy efficiency programs among program participants, or a higher rate of participation among the treatment group compared to the comparison group. Increased participation in other DESC energy efficiency programs among the treatment participants would mean that some portion of savings from other programs may be counted by both the HER program (through the billing analysis savings estimate) and other DESC programs (through deemed savings in their tracking databases).

²⁰ This includes usage by the treatment group prior to participation, and usage by the comparison group during the entire period before and after the treatment group's participation.

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Participation Lift Analysis

To determine whether the HER program treatment generates lift in other energy efficiency programs, the Evaluation Team calculated whether more treatment than comparison group members initiated participation in other DESC energy efficiency programs after the start of the HER program in PY3 compared to the pre-period (i.e., prior to receiving a HER). The Evaluation Team cross-referenced the databases of the HER behavioral program—both treatment and comparison groups—with the databases of other DESC residential energy efficiency programs available to the customer base targeted by the HER program. Programs under evaluation include:

- ARP
- Heating & Cooling (Heating & Cooling Equipment and Ductwork)
- HEC
- ENERGY STAR® Lighting (Online Store, Low-Income LED Kits, and BOL)
- NEEP (Core and Mobile Home Pilot)

The Evaluation Team also included all of DESC's legacy programs because their program participation contributes to the pre-period participation for even the earliest cohort receiving Home Energy Reports.

Through database cross referencing, the Evaluation Team determined whether each program household (both treatment and comparison groups) participated in any program in the pre-period and in PY8. Therefore, participation lift is the difference in treatment versus comparison group participation differences between pre- and post-HER participation (see Table 122 below).

Savings Adjustment Based on Participation Lift

The HER program participants can save energy in three ways: 1) through conservation behaviors, 2) through measures installed outside of an energy efficiency program, and 3) through measures installed as part of other DESC energy efficiency programs.

Although savings through other energy efficiency programs may not have occurred in the absence of the HER program (i.e., if the HER program induces participation), these savings will still be counted by the other programs. The objective of the savings adjustment is to remove savings already captured in other program evaluations.

To determine the net savings component of the participation lift, the Evaluation Team conducted the following steps:

- **Step 1: Determine Overlap in Accounts:** As with the participation lift analysis, the Evaluation Team cross-referenced the database of the HER program, both treatment and comparison groups, with the databases of other DESC residential programs.
- **Step 2: Evaluate Savings of Overlapping Accounts:** Once the overlapping accounts were established, the per-measure (per-program) evaluated net deemed savings were applied to the installed measures to get the KWH savings for both the pre- and post-program period for the treatment and comparison groups. These per-unit KWH savings come from the Residential TRM Lite for 2018. The Evaluation Team applied savings from different program years to the year of the program participation respectively.

Appendices

- **Step 3: Post-Only-Difference (PoD) Approach:** Using the PoD approach, the Evaluation Team calculated the “uplift,” which indicates whether participating in the HER program increased participation in other EE programs. In the PY6 analysis, a Difference-of-Difference (DoD) approach was used. However, since then PoD has become our preferred method of calculating uplift. The PoD calculation uses only current program year EE program participation data. The team found the PoD by subtracting the control group from the treatment group (see Table 122 below). A positive value indicates that participating in the HER program increased participation in other EE programs. The PoD value is then multiplied by the number total number of HER participants to get the uplift value (see equation 2 below). For this analysis, the team found the PoD for each wave of customers (e.g., HER customers that joined in PY6 are one wave of customers, PY7 customers are another wave) and multiplied this by the total number of customers in each wave.

Table 122. HER Post-Only-Differences Estimator

HER Program	Post
Treatment	Y1t
Comparison	Y1c
T-C Difference	Y1t-Y1c

Equation 9. Participation Uplift

Participation Uplift = (PoD for wave) * (Total Number of HER Treatment Participants in Wave)

- **Step 4: Calculate Annual Adjustment:** The Evaluation Team multiplied the median savings (kwh) for each program by the uplift value to get the savings adjustment for each EE program. The savings adjustments for each program add up to the total annual savings adjustment, also called the channeled savings estimate.

Equation 10. Savings Adjustment

Savings Adjustment = (Participation Uplift for Wave) * (Median EE Program Savings Treatment Group of Wave)

The result of this database cross-referencing and calculation is a channeled savings estimate, which is subtracted from the estimate of total program savings. Note that these channeled savings could be attributed to both the HER program and other residential DESC programs, as they would not have occurred unless both programs were operating; however, for accounting purposes only one program can claim these savings.